REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
01-05-2015	Army Science Board	Jan-Sep 2014

4. TITLE AND SUBTITLE

Decisive Army Strategic and Expeditionary Maneuver

5a. CONTRACT NUMBER NA

5b. GRANT NUMBER NA

5c. PROGRAM ELEMENT NUMBER NA

6. AUTHOR(S)

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5d. PROJECT NUMBER NA

5e. TASK NUMBER NA

5f. WORK UNIT NUMBER NA

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Army Science Board
2530 Crystal Dr. Suite 7098
Arlington, VA 22202-3911

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Department of the Army
Office of the Deputy Undersecretary of the Army
Washington, DC 20310-0103

10. SPONSOR/MONITOR'S ACRONYM(S)

HQDA/DUSA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution Statement A. Approved for public release; distribution is unlimited. Refer requests for this document to the Executive Director, Army Science Board, 2530 Crystal Drive, Suite 7098, Arlington, VA 22202-3911.

13. SUPPLEMENTARY NOTES

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14. ABSTRACT

The purpose of the study was to help update the Army's strategy and doctrine around the employment and deployment of forces around the globe. The study team developed four advanced concepts for the Army to consider as the starting point in maintaining its status as the premier, globally-deployable force through 2025: Dynamic, Capability-Based Deployment Planning; Synchronized, Distributed, Interdependent Maneuver; Counter-Digitization; and Adaptive Logistics Support.

15. SUBJECT TERMS

Expeditionary Maneuver; Deployment Planning; Adaptive Logistics Support

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Mark S. Swiatek
U	U	U	UU/SAR	143	19b. TELEPHONE NUMBER *(Include area code)* 7035458651

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18
Adobe Professional 7.0

Army Science Board
Fiscal Year 2014 Study

Decisive Army Strategic and Expeditionary Maneuver

Final Report
May 2015

Department of the Army
Office of the Deputy Under Secretary of the Army
Washington, DC 20310-0103

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DEPARTMENT OF THE ARMY
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ARLINGTON, VA 22202

May 15, 2015

DUSA-ASB

MEMORANDUM FOR SECRETARY OF THE ARMY

SUBJECT: Final Report of the Army Science Board, “Decisive Army Strategic and Expeditionary Maneuver”

1. I’m pleased to forward the final report of the Army Science Board (ASB) study titled “Decisive Army Strategic and Expeditionary Maneuver.” The purpose of the study was to help update the Army’s strategy and doctrine around the employment and deployment of forces around the globe.

2. For this effort, the ASB brought subject matter experts in Physics, Engineering, Computer Science, ISR, Air Defense, Modeling & Simulation, Rapid Manufacturing, Optics, Network Architecture, and a variety of military operations and technologies, as well as former Army leaders. During its seven months together, the study team conducted thirty-five visits and interviews among Army and DoD agencies, Federally Funded Research and Development Centers, Academe, and commercial industry.

3. The study team developed four advanced concepts for the Army to consider as the starting point in maintaining its status as the premier, globally-deployable force through 2025: Dynamic, Capability-Based Deployment Planning; Synchronized, Distributed, Interdependent Maneuver; Counter-Digitization; and Adaptive Logistics Support. The study team also made thirteen findings in the areas of the current operational environment, Army challenges and opportunities, and future trends. From this work, the study team recommended the Army exploit commercial assets for transportation, acquisition of supplies, and communications for the expeditionary force. It also advocated for the development of capability-based planning tools with sufficient granularity (company level and below) to optimize early entry force effectiveness and leverage joint capabilities. The findings and recommendations were adopted by unanimous vote of the ASB on September 18, 2014.

4. I hereby endorse the findings and recommendations in this report.

JA Tegnelia

James A. Tegnelia
Chairman

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EXECUTIVE SUMMARY

This is the report of a study entitled “Decisive Army Strategic and Expeditionary Maneuver,” conducted by the Army Science Board (ASB) under the sponsorship of the Commanding General (CG), U.S. Army Training and Doctrine Command (TRADOC), from October 2013 to September 2014.

The ASB last conducted a study of strategic and expeditionary maneuver in 1999, which focused primarily upon strategic lift. Since that time, the pace of movement of data and information has increased by orders of magnitude, while comparatively, the pace of moving troops and materiel has remained static at best. As technology develops and digitization becomes ubiquitous around the globe, the Army faces the prospect that strategic lift, the key enabler to strategic and expeditionary maneuver, may also become its major constraint. Thus, the focus of this study was not so much on strategic lift, but more generally on what the Army could do to improve the utility of strategic lift assets.

To that end, the Army is interested in understanding what it can do within the bounds of its Title 10 authority to increase and improve its capabilities for strategic and expeditionary maneuver. Seemingly obvious recommendations—such as the acquisition of a new, fast sealift fleet, or a new, strategic airlift capability—are not things that fall within the Army’s exclusive control. Rather, those actions the Army might take on its own (which fall within the standards of the Joint Force) were more pertinent to the objectives of this study. For example, some unilateral actions the Army could take might include lightening and better tailoring its forces, becoming more responsive to expeditionary needs, becoming better able to deploy to austere regions, and being able to fight and win against anti-access and area denial (A2/AD) threats. Given the complexity of strategic and expeditionary maneuver, experimentation with integrated concepts that address these ideas would be critical.

These rather broad areas of inquiry were scaled down and defined by the study’s Terms of Reference (TOR), which directed the ASB to focus its efforts on three tasks:

1. Identify challenges that may compromise the Army’s ability to successfully conduct strategic and expeditionary maneuver in 2025; then examine innovative advanced concepts, critical technologies, systems, and/or processes that might serve as enablers to overcoming those challenges.

2. Identify options for leveraging joint, commercial, and partnering opportunities.

3. Identify technology and engineering innovations for 2025 and beyond currently being researched by the Army or elsewhere within DoD, by other US Government agencies, and by industry, universities, and Federally Funded Research and Development Centers (FFRDCs).

It’s important to note the timeframe for this study, from the present to 2025, and the implicit constraints imposed by that timeframe. As the study team considered a challenge, solution sets

were limited to technologies that are either in the force today, or that are about to become available to the force, because there's simply not enough time to leverage technologies that are not sufficiently mature today. That said, it was still necessary to have some idea of what the world would look like in 2025, particularly with regard to the capabilities of potential adversaries and threats, and the challenges the Army would have to overcome.

To start building the context for what the Army will face in 2025, the study team adopted three key assumptions: (1) that there would be no additional military strategic air and/or sea lift than is available in the force today; (2) that sustainment supplies would be available to ship when needed (i.e., the study team did not consider the time needed to obtain the supplies); and (3) that budgets and force structure would follow current trends.

To identify the challenges facing the Army in 2025, the study team examined two documents: the 2012 Joint Operational Access Concept (JOAC), and the 2014 Joint Concept for Entry Operations (JCEO). From these, the team noted three overarching challenges:

1. The dramatic improvement and proliferation of weapons and other technologies capable of denying access (A2) or freedom within an operational area (AD).

2. The changing U.S. overseas defense posture
    - Decreased support abroad for U.S. military bases
    - Unaffordability of garrisoning forces around the globe to counter every plausible threat
    - In an age of increased terrorism, vulnerability of U.S. forces on foreign soil

3. The emergence of space and cyberspace as increasingly important and contested domains, which are priorities of many future adversaries, both state and non-state.

Finally, the study team identified four key trends that added granularity to its model of operational considerations for 2025: (1) increased urbanization and the growth of mega-cities; (2) the proliferation of advanced technology, including ubiquitous access to information technology; (3) increased momentum of human interaction yielding compressed decision cycles and response times; and (4) improvements to capacity and efficiency in commercial air- and sea-lift.

Drawing from the assumptions, challenges, and trends, the study team developed a model of the operating environment in 2025, against which it ran analyses to determine how the Army would successfully conduct strategic and expeditionary maneuver in that environment. The team concluded the Army should concentrate upon four advanced concepts now to maintain its status as the premier, globally-deployable force in 2025 (Figure 1). These concepts will necessarily require further analysis and experimentation to be implemented successfully.

	CHALLENGES	CONCEPT	ENABLERS
Dynamic Capability-Based Deployment Planning	• Optimizing use of limited air- and sea-lift • Units often take more personnel and equipment than needed for mission • Limited number of tools to enable planners to quickly tailor the force package • Deployment is often not included in training/ exercises	• Forces better tailored to mission to optimize assets deployed • Permits prioritized, phased arrival of capabilities • Permits identification of sub-elements that may be unneeded	• Structured database to identify enabling capabilities (GFM-DI) • Adjusted planning factors to support capabilities • Warfighting simulation to rapidly assess alternative force packages • Tool to assess deployment times associated with force packages (JFAST) • Dynamic tool to convert force packages, and sustainment, into JOPES • Training and exercises to explore tailoring, equipment loading, and rapid deployment • Integration of components above
Synchronized Distributed Interdependent Maneuver	• Avoiding predictable points of entry that become targets for A2/AD threats • Vulnerability of massed forces at single entry point; easily targeted by relatively unsophisticated ISR • Growth of mega-cities as likely maneuver spaces	• Utilize small, mission-tailored units that are deployable into distributed entry points, including mega-cities • Maneuver interdependently to mass forces and close on the objective • Enhance small unit survivability through denial and deception • Enhance small unit lethality to enable immediate punch upon entry	• Advanced Kinetic Munitions • Manned/Unmanned Teaming w/ semi-autonomous Lethal UGVs • Vertical Lift & Precision Airdrop • Deception ops (decoys, info ops, cyber) • Aerial Comms Layer • Mission Command on the Move
Counter-Digitization	• Mitigating digital vulnerabilities across all phases of strategic and expeditionary maneuver owing to US reliance on digital systems • Exploiting similar vulnerabilities owing to adversary reliance	• Develop and grow an organic capability within the BCT to integrate fully kinetic, cyber (defensive and offensive), and electronic warfare effects • New approach to combined arms; potential game changer • Identify and better address cyber vulnerabilities in embedded Programmable Logic devices in weapons systems	• Counter-Navigation Technologies • Counter-Command & Control (C2) • Directed Energy • Electronic Battle Damage Assessment (BDA) • Exploiting "Internet of things" in a secure manner
Adaptive Logistics Support	• Strategic air and sea lift capacity is limited • Consumables demand a significant fraction of lift, especially fuel and water • Deployable communications infrastructure is heavy	• Exploit current commercial transportation trends to "change the game" • Reduce the amount of consumables deployed over long distances - Exploit local resources (e.g., bottling plants) whenever possible - Reduced platform level demand via fuel efficiencies • Exploit commercial communications assets	• Commercial air cargo; shipping for mobile prepo • New expeditionary procurement agility to enable adaptation to local conditions and long-lead contracting • Energy-efficient platforms • Water production, use, reuse • Commercially available bandwidth and devices • Data-mining and analytics • Manufacturing in theater, e.g., selective 3D printing

Figure 1 Advanced Concepts with Associated Challenges and Enablers

The first concept focuses on how the Army prepares to take what it needs for the fight. The study team adopted the phrase "**Dynamic, Capabilities-Based, Deployment Planning**" to emphasize a process that automates mission-tailoring of deployment packages. The team learned from Combatant Commands (COCOMs) and the Army Service Component Commands (ASCCs) that the deployment planning process, specifically for Phases 0 - III, is unaccommodating for users. That is, a lack of visibility into the Army's capabilities at lower echelons makes it difficult to tailor force packages in real time to meet COCOM requirements while "optimizing" the packages to avoid bringing excess equipment. The study team believes the Army can implement a deployment modeling process that would permit a prioritized, phased arrival of capabilities and identify organizational sub-elements that may be unneeded. A key to this process would be a database linking force enablers to subordinate organizations within the Army's Table of Equipment (TOE), along with simulations to evaluate force effectiveness and model transport options. These analytic tools need to have sufficient fidelity to explore options, but need not have the same level of detail as TRANSCOM planning tools.

The second concept, "**Synchronized, Distributed, Interdependent Maneuver**," addresses the challenges of gaining entry into an area of operations (AO) with A2/AD threats. Effective responses to these types of environments requires the unpredictable initial entry of tailored forces via multiple incursion points, rather than massed entry at predictable locations. In turn, these smaller, "smarter" forces will secure lodgment for a more massed entry of reinforcing and follow-on forces. The vanguard forces, despite being distributed around the AO, must conduct synchronized operations immediately upon entry, and do so effectively across a spectrum of scenarios and environments, including urban warfare in mega-cities. The study team believes this concept may be implemented under the current Army force structure by redesigning some forces and making appropriate changes in tactics, techniques, and procedures (TTPs). Furthermore, the team has identified improvements in mission effectiveness and reductions in lift burden that will be enabled by the development of near-term technologies, systems, and processes, which should be fielded by 2025.

The third concept, "**Counter-Digitization**," makes use of the increasing prevalence of digital systems in all aspects of human life. As 21st Century armies, especially the U.S. Army, become more reliant on systems that embed digital functionality, they become more vulnerable to new threats against those systems. Both software and hardware can be exploited to subvert functionality, and as digital systems increasingly connect to networks through wireless means, users are increasingly at risk of attack through remote channels. This creates a critical need for the U.S. Army to reduce digital vulnerabilities going forward, but it also creates a window of opportunity for the Army to achieve technical overmatch and operational advantage against digitally-armed nation- and non-nation-state adversaries. Counter-Digitization transcends cyber or electronic warfare alone; it involves far more than simply securing networks for assured communications or applying electronic countermeasures or counter-countermeasures against selected targets. Rather, Counter-Digitization harnesses the full potential of offensive and defensive means to exploit an adversary's digital hardware, software, and gateways while securing your own. The key to implementing this concept for the Army is full integration among kinetic, cyber, and electronic warfare effects at the tactical level.[1] It is consistent with the Army's emerging doctrine of Cyber Electromagnetic Activities (CEMA), but extends it to echelons lower in

[1] The team notes that there is an ongoing ASB study, scheduled to complete in FY 2015, that covers Army defensive and offensive cyber activities at the tactical edge, and which deals with aspects of this question in more detail.

the organization than brigade. In effect, Counter-Digitization entails a new approach to combined arms warfare.

The fourth concept, "**Adaptive Logistics Support**," seeks to address the burden of sustaining the maneuver force. There are several options for reducing the distance over which supplies and materials must be transported, as well as for reducing the amount of supplies and materiel needed to support forward-deployed forces. The study team noted that water and fuel accounted for a significant portion (36-45%) of Brigade Combat Team (BCT) tonnage, which included 30-days of sustainment. This is significant because any actions the Army takes to relieve the lift burden of fuel and water will free up space for additional personnel and/or equipment to arrive earlier. Along the same lines, the team also considered the availability of local communications infrastructure to reduce the sustainment burden.

Beyond the concepts, the study team identified opportunities for leveraging Joint, commercial, and foreign nation partnerships. For example, the Army could actively seek partners to preposition supplies and materiel, and for building sustainment infrastructure within AOs. In addition, 10 areas of technological innovation were identified that, once matured, could improve strategic and expeditionary maneuver in the timeframe of 2025 and beyond.

During the course of its investigation, the study team identified 13 major findings (Figure 2):

FINDING	POTENTIAL IMPLICATION
CURRENT ENVIRONMENT	
CONUS basing and/or austere conditions severely constrain force size that can be deployed during initial entry	• Tailoring forces and sustainment maximizes mission effectiveness of initial entry forces • Availability of Joint capabilities frees up capacity for high-priority Army capabilities
Proliferation of A2/AD threats affects early entry operations significantly.	Conventional approaches involving the massing of forces in predictable ports of debarkation are especially vulnerable
Mission command is critical to expeditionary maneuver	Historical overmatch in this area is eroding with the advent of social media and the ubiquitous spread of information technology
ARMY CHALLENGES & OPPORTUNITIES	
Vertical lift is an essential enabler for synchronized distributed interdependent maneuver via unpredictable entry points	Reliance on traditional points of embarkation
Stovepipes resulting from Title 10 vs. Title 50 authorities disallow tactical exercises in the US that employ Title 50 systems	Impede warfighting functions critical to expeditionary maneuver
Partnering with other nations, non-governmental organizations, and commercial entities can enhance regional stability and may enable additional options for prepositioning, stationing, and sustainment support	Critical in austere and/or unfamiliar environments
Navy FY15 POM eliminates National Defense Sealift Fund, used in past to maintain surge sealift	• Funding transferred to Navy O&M Ready Reserve Force ($291M) and Ship Pre-positioning and Surge ($106M) accounts • Contrary to prior Army/Navy agreements

Figure 2 Study Findings

FINDING	POTENTIAL IMPLICATION
FUTURE TRENDS	
Cyber and other digital systems will be increasingly subject to exploitation, denial, deception, and negation in 2025, exacerbated by reliance on commercial capabilities	Offers both opportunities and challenges for strategic and expeditionary maneuver
Mega-cities will confront the Army with new challenges requiring specialized and intensive pre-planning, advanced analytics, and regular training	Must operate in three-dimensional urban terrain, with intermingled adversaries and non-combatants, employing complex rules of engagement applied to a highly dynamic environment
By 2025, commercial advancements in many key areas will outpace those driven by the Army and DoD	Among others, mobile communications, cargo aircraft and ships, and commercial information technology can enhance significantly strategic and expeditionary maneuver
By 2025, DoD-sponsored advancements in selected areas will have matured to the point where they can be incorporated into Army operations	Semi-autonomous systems, hybrid-powered platforms, aerial layer communications and networking, precision fires/munitions all hold promise for reducing logistics burden
Beyond 2025, DoD-sponsored advancements in additional selected areas will have matured to the point where they can be incorporated into Army operations	Unmanned vertical heavy lift (25-30 ston payload), advanced directed energy weapons, etc.
Globalization may provide an opportunity to harness resource availability around the world (e.g., bottling plants, cellular providers)	Offsets logistics burden by taking advantage of indigenous resources

Figure 2 Study Findings (Cont.)

Based on its findings, the study team recommends the following actions be taken (Figure 3):

OFFICE	RECOMMENDED ACTION
Chief of Staff of the Army (CSA)	Advocate for maintaining National Defense Sealift Fund to sustain capability for surge sealift; coordinate with Joint community[2]
Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT))	• Ensure key technologies (e.g., semi-autonomous systems, hybrid-powered platforms, aerial layer communications and networking, precision fires/munitions) are addressed in BA4, BA3 (and BA2) funding plans • In coordination with USTRANSCOM, AMC, G3/5/7, G4, and DLA: Develop the strategy and business case to exploit commercial assets for transportation, acquisition of supplies, and communications for the expeditionary force; consider new and improved vehicles to enable "contracting at the speed of expeditionary maneuver"
Commanding General, Forces Command (CG FORSCOM)	• With support from G3/5/7: Develop capability-based planning tools with sufficient granularity (company level and below) to optimize early entry force effectiveness and leverage joint capabilities (fire support, ISR, medical services) whenever possible; accelerate and expand Global Force Management Data Initiative to meet this purpose • Execute Emergency Deployment Readiness Exercises (EDREs)

Figure 3 Study Recommendations

[2] After the findings and recommendations for this study were voted on and adopted by the ASB in September 2014, Congress included funding for the National Defense Sealift Fund in the FY15 omnibus budget, and the President's budget request for FY16 also includes the National Defense Sealift Fund. Continued monitoring by the Army is prudent to ensure the funds are not re-allocated.

OFFICE	RECOMMENDED ACTION
Commanding General, Training and Doctrine Command (CG TRADOC)	• Develop and conduct Joint Concept Technology Demonstrations (JCTDs) and/or warfighting experiments for each of the four concepts identified in this study • Integrate the most promising concepts in end-to-end experiments • Evaluate BCT force structure to determine if current force design supports expeditionary distributed operations using smaller units (company level and below) • In coordination with G3/5/7, G2, and G6: Develop doctrine, training, TTPs, and technical capabilities to integrate kinetic, cyber, and electronic warfare effects as an organic BCT tactical capability to be incorporated in all operational planning; new approach to combined arms • Develop integrated and interdependent CONOPS and evaluate operational utility for distributed maneuver using near-term non-developmental items (NDIs) for vertical lift and precision airdrop; initiate requirements assessment for a future unmanned heavy lift vertical system for JLOTS and mounted vertical maneuver
Director, Army Capabilities Integration Center (ARCIC)	In coordination with RDECOM: Beginning with concepts identified in this study, conduct detailed DOTMLPF analysis on concepts and enablers by end of 2015
Army Deputy Chief of Staff, Operations, Plans and Training (G3/5/7)	• Set requirement to reinstitute Emergency Deployment Readiness Exercises (EDREs) • Review readiness issues resulting from Title 10/Title 50 authorities and, as required, articulate path forward to remove constraints on CONUS-based BCT training with Title 50 systems • Designate a specialized BCT test bed for expeditionary urban operations to develop doctrine and training required for operating in mega-cities; leverage Army National Guard presence in US mega-cities for relevant civilian skillsets • In coordination with USTRANSCOM, AMC and DLA: Expand concepts for strategic partnering to leverage partner contributions (including logistics) in future operations • With G4 and TRADOC: Review sustainment planning factors for deployment in expeditionary maneuver
Commanding General, Maneuver Center of Excellence (CG Maneuver COE)	With support from CG Cyber COE: Make counter-digitization part of the maneuver, fire, and effects warfighting function

Figure 3 Study Recommendations (Cont.)

1.0 INTRODUCTION

The Army Science Board (ASB) last addressed strategic maneuver in a 1999 study titled "Enabling Decisive Strategic Maneuver for the Army Beyond 2010."[3] That study assisted Army senior leaders as they made a number of decisions to set the Army's path for the 21st Century. Since then, the Army has conducted "The Army After Next"[4] studies, created the Objective Force Task Force,[5] developed and equipped the 4th ID with the Stryker,[6] initiated and terminated the Future Combat Systems program, made plans for a new Ground Combat Vehicle, and acquired vast lessons learned from over 13 years of operations in Iraq and Afghanistan.[7] However, since 1999, the Army's capability to strategically deploy an operationally relevant force in a timely manner has stagnated, if not diminished.

In revisiting decisive strategic maneuver for this year's study, the ASB has been tasked to consider those gaps that may have emerged over the last 15 years, but the primary focus is the future, specifically, 2025 and beyond. Looking ahead, a major element of national security strategy involves a pivot to the Pacific,[8] reflecting the belief that U.S. foreign policy, national security, and economic interests are realigning and shifting towards Asia. The US military has responded accordingly. DoD is focused on countering a major threat in the region, anti-access/area-denial (A2/AD) weapons and tactics, which may be employed by both nations and non-state actors to hamper the deployment of ground troops. Consequently, the Air Force and Navy have unveiled their Air Sea Battle concept[9] to address A2/AD, and the Army's recent Unified Quest exercise[10] tested the Army's ability to perform rapid, timely, decisive maneuver to Asia, the Middle East, and other areas of the globe.

Another prevailing condition for 2025 the study team considered was constrained U.S. defense resources, which threaten to reduce U.S. military capacity in various parts of the world. Lacking the ability to foresee future fiscal crises, any budgetary considerations military planners apply today may run up against even more restrictive funding constraints. Thus, the challenge to Combatant Commanders and the Army going forward will be to deploy a force that can rapidly respond to events occurring anywhere around the globe, in a Joint A2/AD environment, using maneuver support systems and infrastructure that may bear the brunt of budget cuts over the next several fiscal cycles.

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[3] Army Science Board FY 1999 Summer Study Final Report Enabling Decisive Strategic Maneuver for the Army Beyond 2010, August 1999, DTIC ADA373858.

[4] John Matsumura, et al., The Army After Next: Exploring New Concepts and Technologies for the Light Battle Force. Rand Army Research Division, 1999.

[5] An analysis of the Objective Force can be found in the Army Transformation Wargame 2001 US Army War College, Carlisle Barracks, PA (22-27 April 2001).

[6] See "Bring on the Strykers;1st BCT, 4th ID Switches Mission" by Michelle Tan in The Army Times, January 22, 2014.

[7] Available at the Center for Army Lessons Learned website: http://usacac.army.mil/organizations/mccoe/call

[8] Sustaining U.S. Global Leadership: Priorities for 21st Century Defense. U.S. Department of Defense (January 2012).

[9] Quadrennial Defense Review Report. U.S. Department of Defense (February 2010).

[10] Unified Quest 2013: Deep Future Wargame 2030-2040 Executive Report. U.S. Army War College, Carlisle Barracks, PA (15-20 September 2013).

1.1 TERMS OF REFERENCE (TOR) AND ASSUMPTIONS

The Commanding General (CG), U.S. Army Training and Doctrine Command (TRADOC), sponsored this study. His terms of reference (TOR) (see Appendix B), designate three tasks for the study team:

1. TASK 1: Identify the challenges that may compromise the operational forces' ability to successfully conduct strategic and expeditionary maneuver in 2025; recommend innovative advanced concepts; identify critical technologies, systems, and/or processes that might serve as enablers.
2. TASK 2: Identify options to leverage joint, commercial, and partnering opportunities.
3. TASK 3: Identify Army, other DoD, other USG, industry, university, and FFRDC research, technology, engineering and innovations for 2025 and beyond.

The TOR further stipulates that the study should be performed "assuming no more military strategic air and sea lift than in the force today." Additionally, the study team assumed that:

1. Sustainment supplies will be available to ship when needed (i.e., the team did not consider the time needed to obtain the supplies), and
2. Budgets and force structure will follow current trends (i.e., the team focused on concepts and enablers that would not require major development programs).

1.2 METHODOLOGY

The study team's approach to fulfilling the TOR consisted of seven measures (Figure 1.1).

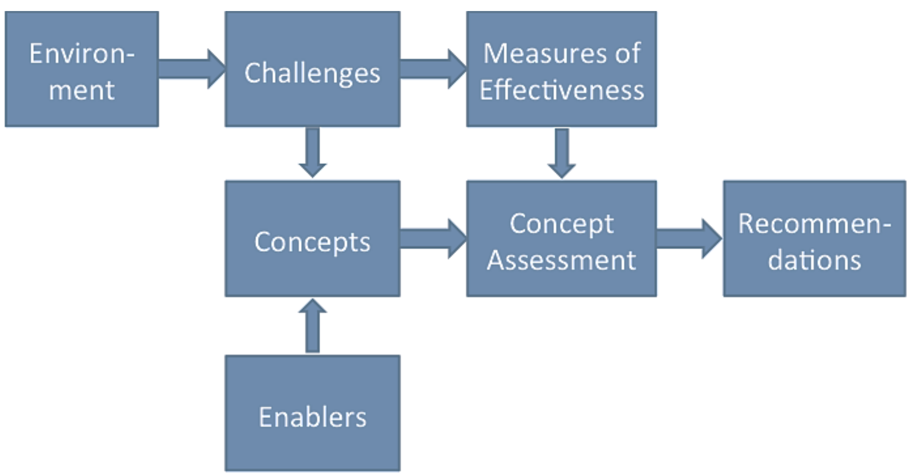

Figure 1.1 Study Methodology

First, the team identified environmental conditions in 2025 and beyond that will shape the operational climate (weapons, technologies, TTP, etc.), as well as the domestic conditions (fiscal and political constraints, technological advances, commercial industry, etc.), shaping the range of options available to potential adversaries and the Army.

Second, the study team derived several challenges (further discussed in Section 2 below), that emerged from those proposed environmental conditions, including:

- Proliferation of A2/AD threats
- CONUS-basing of forces
- Potential conflicts in austere areas and/or areas with minimal infrastructure
- Crises springing up on short notice, aided by ubiquitous access to social media

Third, the study team developed several advanced concepts, motivated by the challenges, which would support the Army in maintaining its status as the premier, globally-deployable force in 2025. After extensive review, the study team settled on four advanced concepts (further discussed in Section 3 below): 1. Dynamic, Capabilities-Based, Deployment Planning; 2. Synchronized, Distributed, Interdependent Maneuver; 3. Counter-Digitization; and 4. Adaptive Logistics Support.

Concurrently, the fourth step involved identifying technologies, systems, and processes that support and enable the concepts (further discussed in Section 3 below).

The study team also developed measures of effectiveness (MOEs) for overcoming the challenges against which the advanced concepts would be assessed. The MOEs reflect elements required for improving strategic maneuver; thus the more MOEs a concept fulfills, the stronger the concept:

1. Time to Employ – evaluates whether the concept reduces the time for material to move through the stages of deployment (Figure 1.2) to the point where it can be employed. It includes time to prepare the unit for employment after arrival in theater as well as time to deploy.

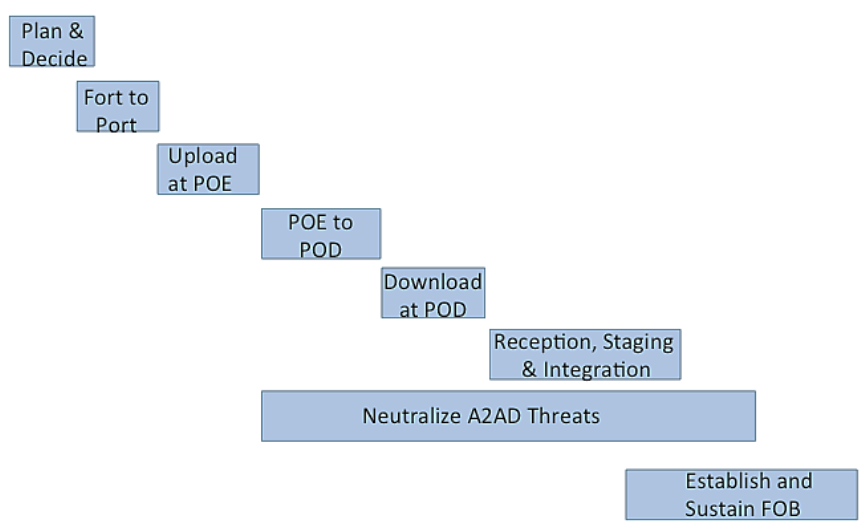

Figure 1.2 Stages of Deployment

2. Mission Effectiveness – evaluates whether the concept enhances unit effectiveness (increased lethality or survivability). It also addresses whether deployability is enhanced at the expense of mission effectiveness.
3. Technical Maturity – evaluates whether the technologies that enable the concept are sufficiently mature to field by 2025.
4. Cost – evaluates whether the concept incurs unaffordable life cycle costs, including research and development, procurement, and sustainment.
5. Mission Flexibility Across Full Spectrum of Conflict – evaluates whether the concept applies to all phases of conflict from Phase 0 (Shape the Environment), through Phase 1 (Deter the Enemy), Phase 2 (Seize the Initiative), Phase 3 (Dominate the Enemy), Phase 4 (Stabilize the Environment), to Phase 5 (Enable Civil Authority).
6. Capability Against A2/AD Threats and Other Counters – evaluates whether the concept is robust against such threats.
7. US Army Dependency on Outside Funding or Operations – reflects Army desire to be self-sufficient.
8. Ethical, Legal, and Social Acceptability – ensures that the concept doesn't exceed limits imposed in areas such as privacy issues, rules of engagement (ROE), and international treaties.
9. Sustainment of the Force (Maintainability, Medical, Contract) – addresses whether the concept leads to increased sustainment requirements.

The study team used the first two MOEs (time to employ and mission effectiveness) as touchstones for developing the advanced concepts. The remaining seven MOEs were used to evaluate whether the Army would have to pay too dearly for the improvement provided by the concept. For example, one option to reduce the time required would be to change the lift platform(s) to ones with greater capacity or greater speed. However, such platforms are not currently mature (MOE #3) and the cost to develop and procure them would be prohibitive (MOE #4). Thus, the concept was not developed any further.

The sixth step involved assessing concepts against the MOEs (further discussed in Section 4 below), and selecting the concepts that fulfilled the MOEs.

Finally, the study team developed findings and recommendations (discussed in Section 7 below) to promote the advanced concepts.

1.3 DEFINITIONS OF KEY TERMS

The terms "strategic and expeditionary maneuver" are defined in the TOR as follows:

- Strategic Maneuver – the agile posturing and employment of forces and capabilities, in all domains on a global scale, to gain and maintain physical, temporal and psychological advantage over potential adversaries.
- Expeditionary Maneuver – the rapid deployment of scalable or tailored, operationally and tactically significant forces, on short notice, to austere locations, in order to conduct any type of operation immediately upon arrival, often in persistent A2AD environments. (The study team further defined "rapid" to be less than or equal to 30 days.)

Furthermore, the study team found it necessary to differentiate between the terms enabler and concept:

- Concept – system-level operational solution designed to meet the mission objectives. A concept integrates multiple enablers.
- Enablers – critical technologies, systems and/or processes necessary to meet the mission objectives.

1.4 STUDY TEAM MEMBERS AND VISITS

The study was conducted by 18 ASB members drawn from Academia, FFRDCs, National Laboratories, defense contractors, and retired military and government officials (Appendix C). As such, the team brought expertise in Physics, Engineering, Computer Science, Optics, Systems Engineering and Integration, Aerospace Technology, Materials, Modeling and Simulation, Rapid Manufacturing, Network Architecture, National Security, ISR, Air Defense, Analytics, Robotics, Autonomy, Program Management, Military Space, Missile Systems, Munitions, Sensors, Logistics, Acquisition, and Sustainment.

Over the course of the study, team members met with over 40 organizations:

- OSD/Joint organizations:
  - Joint Chiefs of Staff, J8
  - United States Central Command (CENTCOM)
  - United States Army, Pacific Command (USARPAC)
  - United States Army, European Command (USAREUR)
  - United States Special Operations Command (SOCOM)
  - United States Transportation Command (TRANSCOM)
  - Defense Advanced Research Projects Agency (DARPA)
  - Office of the Secretary of Defense, Rapid Fielding
  - Office of the Secretary of Defense, Program Support (DASD-PS)
- Army Organizations:
  - G3/5/7
  - 82nd Airborne Division
  - 1st Brigade, 4th Infantry Division
  - Combined Arms Support Command (CASCOM)
  - Training and Doctrine Command (TRADOC)
  - Army Capabilities Integration Center (ARCIC)
  - Army Forces Command (FORSCOM)
  - Army Sustainment Command (ASC)
  - Army Cyber Command (ARCYBER)
  - Maneuver Center of Excellence (MCOE)
  - Army Research Laboratory (ARL)
  - Armament Research, Development, and Engineering Center (ARDEC)
  - Aviation and Missile Research, Development, and Engineering Center (AMRDEC)

  - Communications-Electronics Research, Development, and Engineering Center (CERDEC)
  - Natick Soldier Research, Development, and Engineering Center (NSRDEC)
  - Tank Automotive Research, Development, and Engineering Center (TARDEC)
  - Army War College
  - Army Chief of Staff's Army Strategic Studies Group
- FFRDCs/Academia:
  - RAND Corporation
  - MITRE Corporation
  - Georgia Tech Research Institute (GTRI)
- Industry:
  - Google
  - The Boeing Company
  - Association of the United States Army (AUSA)
  - National Defense Industrial Association (NDIA)
  - TEQ Games
  - Maersk
  - Amazon
  - NYK Lines
  - Hapag Lloyd Lines
  - Journal of Commerce

The team also received written input from FFRDCs, Think Tanks, and Laboratories:

- Brookings Institution
- Center for Naval Analyses (CNA)
- Institute for Defense Analyses (IDA)
- Los Alamos National Laboratory (LANL)
- Lawrence Livermore National Laboratory (LLNL)
- MITRE Corporation
- RAND Corporation
- Sandia National Laboratories (SNL)

2.0 CHALLENGES AND TRENDS

The study team used two joint documents, the Joint Operational Access Concept (JOAC)[11] and the Joint Concept for Entry Operations (JCEO),[12] to identify overarching challenges:

1. The dramatic improvement and proliferation of weapons and other technologies capable of denying access (A2) or freedom within an operational area (AD)
2. The changing U.S. overseas defense posture (CONUS-basing of forces)
   - Decreased support abroad for U.S. military bases
   - Unaffordability of garrisoning forces around the globe in response to every threat
   - In age of increased terrorism, vulnerability of U.S. forces on foreign soil
3. Potential conflicts in austere areas and/or areas with minimal infrastructure
4. The emergence of space and cyberspace as increasingly important and contested domains for many future adversaries, both state and non-state actors
5. Crises springing up on short notice, aided by ubiquitous access to social media

The Army validated the relevance of these challenges to its operations in the recently released Army Operating Concept.[13]

2.1 GEOPOLITICAL/PHYSICAL/TECHNICAL CHALLENGES

Each of the identified challenges affects closure time, that is, the point when the supported commander determines that the deploying force has completed movement to the specified AO or destination with sufficient resources, and is ready to conduct its assigned mission. An assessment of closure times for the Stryker Brigade Combat Team (SBCT) (Appendix E) revealed airlift is the sole mode of transport that delivered the closure complement of SBCT equipment within 27 days, which met the study's definition of rapid deployment (≤30 days). A comparison of deployment times of five postulated missions (Figure 2.1) provides insight into how the variable modes of transport affect strategic maneuver. For example, the use of surface or intermodal (more than one mode of transport) sealift to Slovakia, where the area of deployment is within driving distance of a major port, produces the fastest delivery of the complete SBCT. In contrast, intermodal deployment to Bangui produces the longest time of deployment because the airlift following sealift is time-consuming. Based upon these comparisons, the study team focused on airlift to achieve rapid deployment.

[11] Joint Operational Access Concept (JOAC), Version 1.0, Department of Defense, 17 January 2012.
[12] Joint Concept for Entry Operations (JCEO), Joint Chiefs of Staff, 7 April 2014.
[13] TRADOC Pamphlet 525-3-1, The US Army Operating Concept: Win in a Complex World – 2020-2040, 7 Oct 2014.

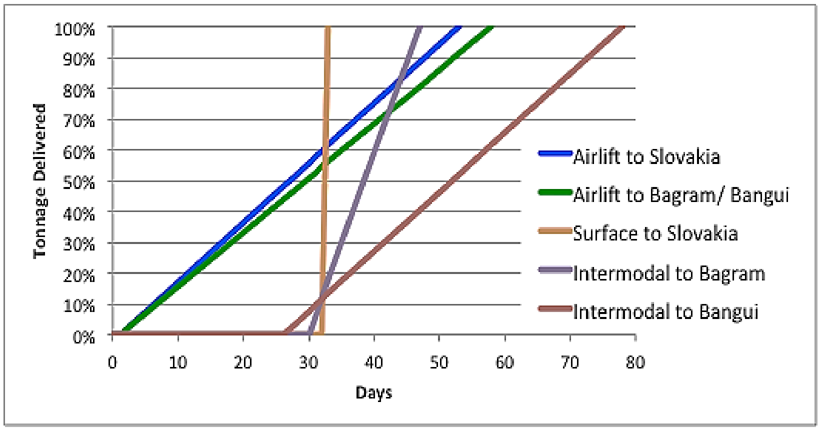

Figure 2.1 SBCT Deployability Summary[14]

Reliance upon airlift for rapid deployment will continue for the foreseeable future, because as US forces consolidate and become increasingly CONUS-based, the distance over which those forces deploy will continue to increase. Airlift will provide the best mode of transport, but has inherent limitations. For example, the distance from Joint Base Lewis/ McChord to Central Africa is slightly over 7,000 nautical miles (nmi). Using C-17 aircraft and assuming the air ports of debarkation (APODs) do not constrain the deployment, it would require moving approximately 890 short tons per day to close a full SBCT in 30 days. Using baseline estimates of C-17 performance to calculate the tonnage that could be deployed each day,[15] 20 C-17s [16] could deliver 421 short tons per day to 7,000 nmi. Thus, approximately 43 C-17s would be required to close that mission (Figure 2.2).

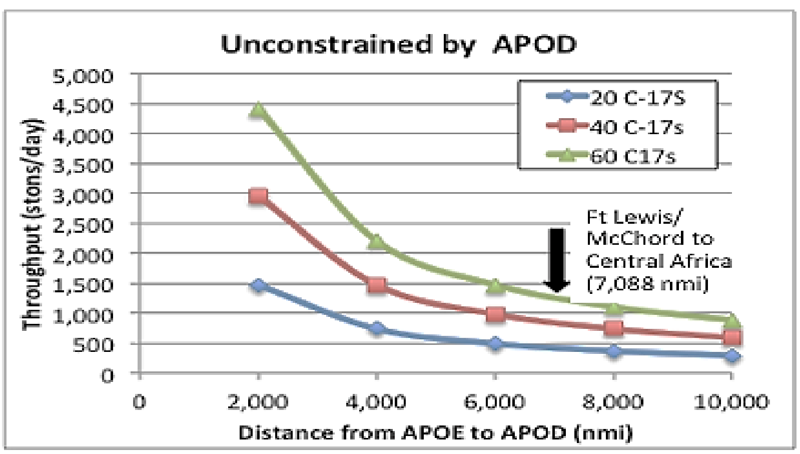

Figure 2.2 Daily Throughput Constrained by Distance[17]

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[14] Data derived from the Stryker Deployability Study, Final Report, 15 August 2011, prepared by Military Surface Deployment and Distribution Command (SDDC), Transportation Engineering Agency (TEA).

[15] Assuming the C-17 flies at 406 nmi/hr, has 50 stons (short tons = 2,000 pounds) average payload, and is limited to 14.5 flight hours per day.

[16] Analysis by the Surface Deployment and Distribution Command (SDDC) assumes that 20 C-17s would be available for a deployment mission, thus the Stryker Deployability study (summarized in Appendix E) assumes "availability of 20 C-17 (CONUS) aircraft daily."

[17] Data derived from the Stryker Deployability Study, Final Report, 15 August 2011, prepared by Military Surface Deployment and Distribution Command (SDDC), Transportation Engineering Agency (TEA).

The illustration above is optimistic in the sense that it doesn't take into account any constraints on the ground at the APODs. Daily throughput would be affected by the capacity of an airfield, or the maximum number of aircraft that an APOD can accommodate, known as maximum on ground (MOG). In this case, the limitation on airpower is a function of supporting logistics, rather than the capabilities of the aircraft. For example, assume the queuing efficiency at an APOD is 85%, and the APOD operates 24 hours per day. If it takes 2 hours on the ground to unload a C-17, and the MOG=1, then throughput is limited to 510 short tons per day. Under those circumstances, it wouldn't be possible to close the full SBCT in 30 days, unless the deploying force made use of more than one APOD (Figure 2.3).

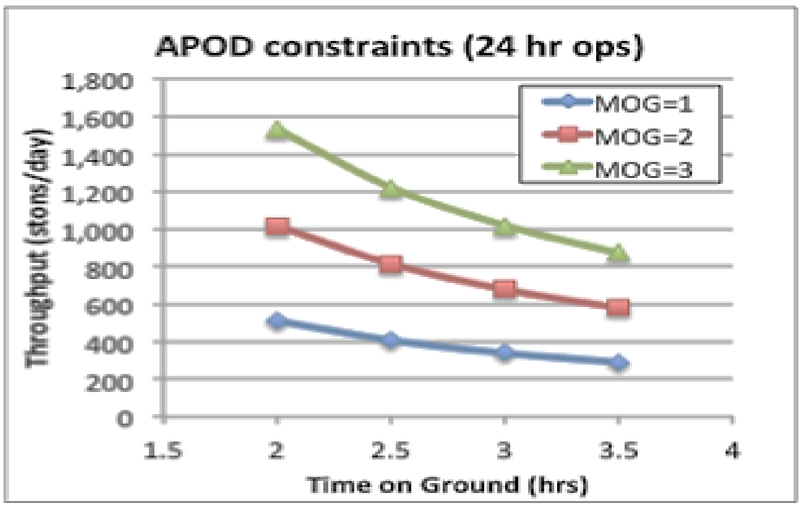

Figure 2.3 Throughput Constrained by the APOD[18]

Beyond sheer tonnage and the distance it must travel, cargo places additional constraints on airpower in terms of the diversity of material and the precise flow that material must move to provide proper support to troops. These factors will vary for each of the three types of BCT, the Infantry BCT (IBCT), Stryker BCT (SBCT) and Armored BCT (ABCT; formerly known as the heavy BCT) (Figure 2.4). One common factor among the three BCT types, the tonnage of equipment that must be transported when the BCT is deployed is comparable to the tonnage associated with sustainment of the BCT for 30 days.

The diversity of cargo may be illustrated by the three types of water that must be transported to the AO: drinking water, other potable water, and non-potable water. Drinking water is estimated at between 4.6 and 6.7 gallons per person, depending upon the climate (arid being most demanding). Other potable water is estimated at between 3.2 and 5.7 gallons per person, which also depends upon climate and the phase of operation. Non-potable water is estimated at between zero and 2.7 gallons per person and likewise varies with climate and phase of the operations. The values shown in the graph below correspond to 3,537 personnel in the IBCT, 4,274 in the SBCT, and 3,756 in the ABCT.

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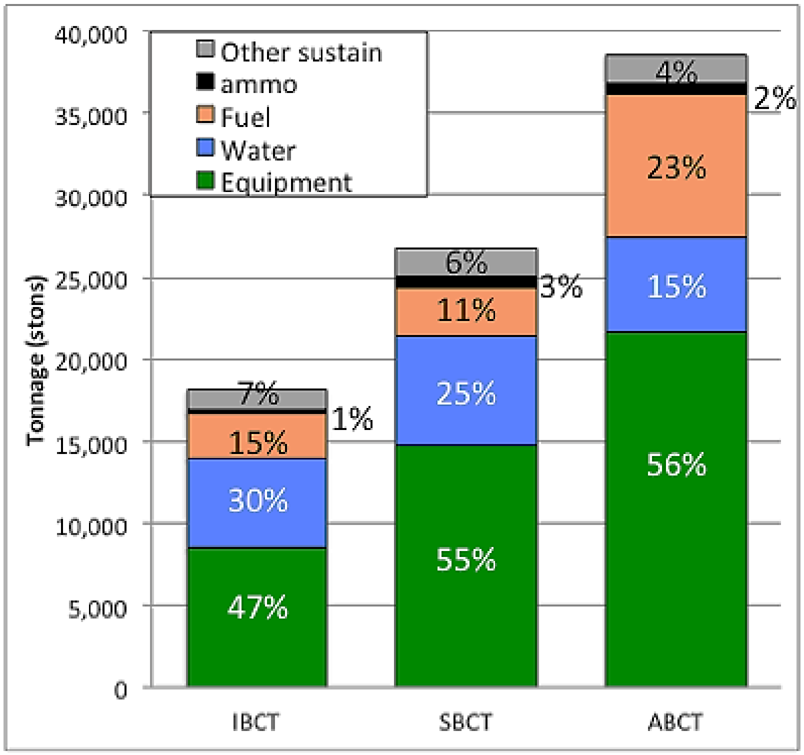
[18] Ibid.



Sustainment Assumptions: Arid climate, Phase I-III Operations, and Max intensity conflict
References: Deployment Planning Guide, SDDCTEA Pamphlet 700-5, 2012 (Equipment), and Quick Logistics Estimation Tool (Sustainment)

Figure 2.4 BCT Tonnage Including 30 Day Sustainment

As with water, the tonnage for fuel and for ammunition vary with the type of BCT, phase of operations, and the intensity of the conflict. Note that the combined tonnage for water, fuel, and ammunition is on the order of 40% of the total, which may provide opportunities for efficiencies and economies of scale.

Under current conditions, the various constraints on airlift limit rapid (≤30 days) deployment of any type of BCT to about 2,000 nautical miles (Figure 2.5). None of the BCTs can be fully deployed to 7,000 nautical miles in 30 days or less. Thus, even with the best option for strategic maneuver, it may be necessary for the BCT to be able to fight without its full complement.

BCT Type	Nominal Weight*	Number C-17 sorties	Days if 2,000 nmi (20 C-17s)	Days if 7,000 nmi (20 C-17s)	% of tonnage to 7,000 nmi in 30 days (20 C-17s)
IBCT	18,192 stons	364	13	44	69%
SBCT	26,705 stons	534	19	64	47%
ABCT	38,489 stons	770	27	92	33%

Assumptions: 50 ston average C-17 payload, 0.7 days/sortie for 4,000 nmi round trip, 2.4 days for 14,000 nmi, APOE and APOD do not constrain throughput

Figure 2.5 Time to Airlift BCTs

A final note on the capacity of US military airlift: there are 213 C-17s in the current USAF fleet, and no new purchases are planned. Additional airlift capabilities reside in the Civil Reserve Air Fleet (CRAF), which consists of commercial aircraft operated by commercial carriers under contract to USTRANSCOM. The use of CRAF creates additional challenges, as the fleet reflects the age, composition, and diversity of the participating carrier's fleet.

2.2 KEY TRENDS PROVIDING ADDITIONAL CHALLENGES AND OPPORTUNITIES

Four trends were identified that will drive future challenges and opportunities:

1. Increased urbanization and growth of mega-cities (population > 10 million)
2. Proliferation of advanced technology, including ubiquitous access to information technology
3. Increased momentum of human interaction; compressed decision cycles and response times
4. Improvements to capacity and efficiency in commercial air- and sea-lift

The first trend, increased urbanization, includes the growth of mega-cities and poses special challenges to military operations, such as terrain with complex layers of tactical engagement[19] where line-of-sight (LOS) satellite links that may be lost in urban canyons, adversaries intermingled with non-combatants, and complex rules of engagement. The United Nations projects 50% growth of mega-cities by 2025, as compared with those in 2010 (Figure 2.6).

[19] See CSA's Future Study Plan entitled *The Megacity: Operational Challenges for Force 2025 and Beyond* (ARCIC; 2014): "At the tactical-level, megacities may be thought of as a complex terrain challenge. Within the megacity, however, terrain has multi-level layers: subsurface, surface, elevated (buildings), and airspace. Additional factors within the megacity are cyber, communication, and information realms. The multi-level terrain and additional complexity factors pose unique challenges."

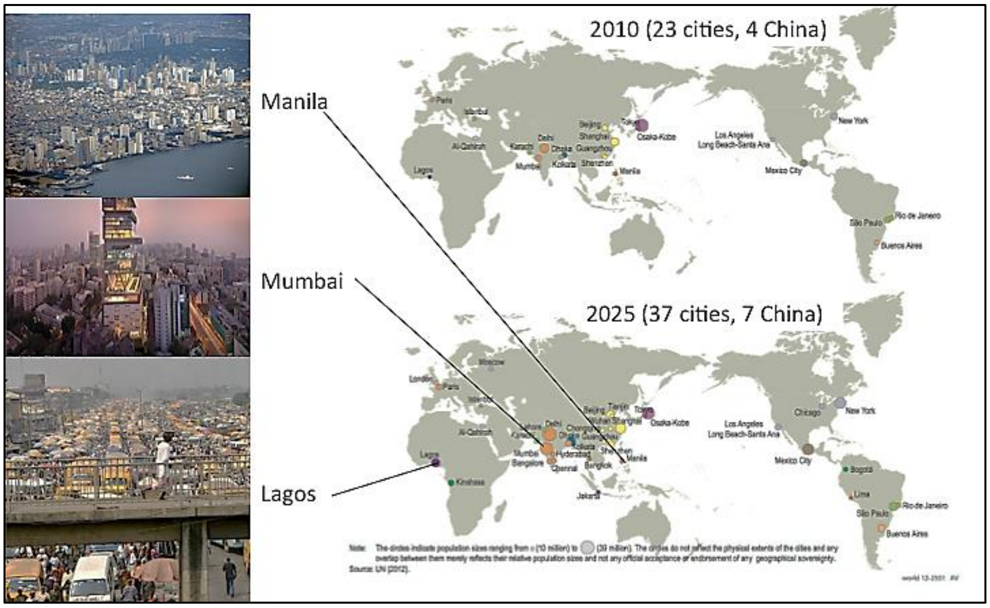


Figure 2.6 The Challenge of Mega-Cities

The second trend, the proliferation of advanced technology, includes both weapons and information technology. Connectivity is expanding to include every country and most individuals. According to Vinton G. Cerf, the Chief Internet Evangelist at Google, "by 2025, you will have a hard time avoiding being connected."[20]

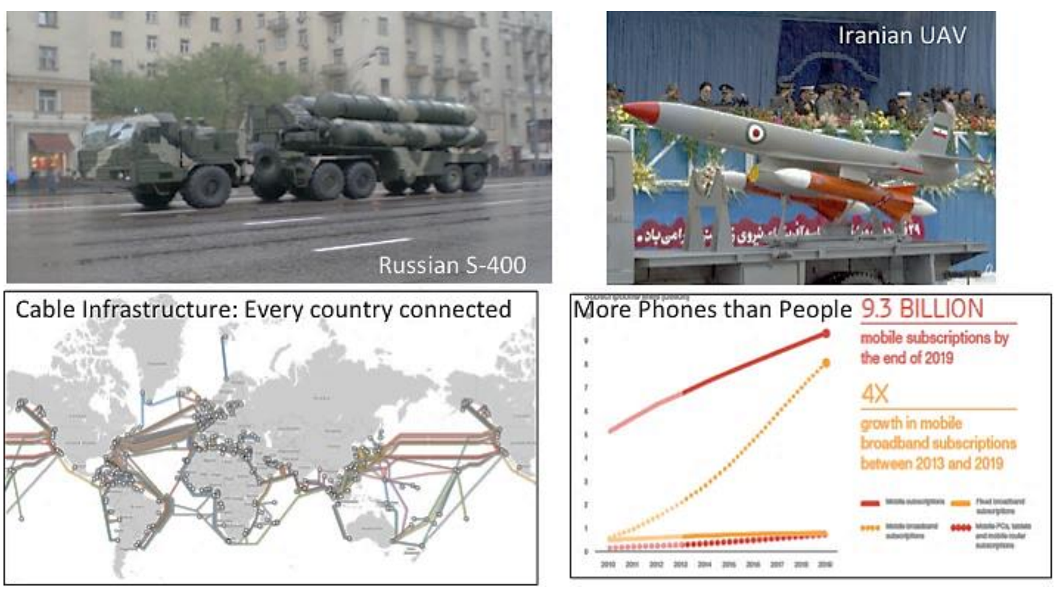


Figure 2.7 Proliferation of Advanced Technology

Expanding connectivity means that events now unfold in "Internet time." Information propagates instantly around the world, reducing decision times and response times. This third trend (Figure

[20] Vinton G. Cerf, personal communication during study team interview at Google, Reston VA, June 2014.

2.8) is broad in the sense that it pertains to many types of social interaction, with many possible outcomes, from the passage of news, to the coordination of an attack. The common element is the speed with which the interactions occur.

Figure 2.8 Increased Human Interaction

The fourth and final trend is occurring in commercial transportation, where significant, emerging changes will impact strategic maneuver by 2025. For example, a rapid transition is occurring in the commercial air cargo market where 777/787-class planes are being employed to move cargo with passengers. These planes can carry either 50 tons of cargo, or 300-400 passengers and 25 tons of cargo. Thus, a significant amount of equipment could be carried in the same aircraft as deploying personnel. This capability will grow worldwide, as standardized containers are becoming the norm; LD3s, LD6s, and LD11s (Figure 2.9) will fit 787s, 777s, 747s, MD-11s, Il-86s, Il-96s, L-1011s and all Airbus wide bodies. Furthermore, projected sales for wide body aircraft amount to $5T over the next 20 years. One supplier indicated that its current booked sales amount to 92 billion ton-miles of commercial airlift (vice 60 million ton-miles cited in the previous DoD mobility requirements study). Unfortunately, this rapid change will have less impact among the CRAF carriers, as the majority of them don't hold order positions on the new, higher payload aircraft.

Name	Volume (cu ft)	Dimensions* (in)	
LD3	159	61.5 / 79 × 60.4 × 64	
LD6	316	125 / 160 × 60.4 × 64	
LD11	253	125 × 60.4 × 64	

* Base width / overall width × depth × height)

Figure 2.9 Air Cargo Container Dimensions

Another example is the emergence of ships that are capable of moving 18,000 to 20,000 twenty-foot containers (TEU) in predominately east/west trade routes, and the corresponding development of north/south feeder routes across the industry (Figure 2.10). The combination of these factors forecasts a sea-based commercial cargo transport system whose capacity and delivery speed will outstrip the current DoD system.

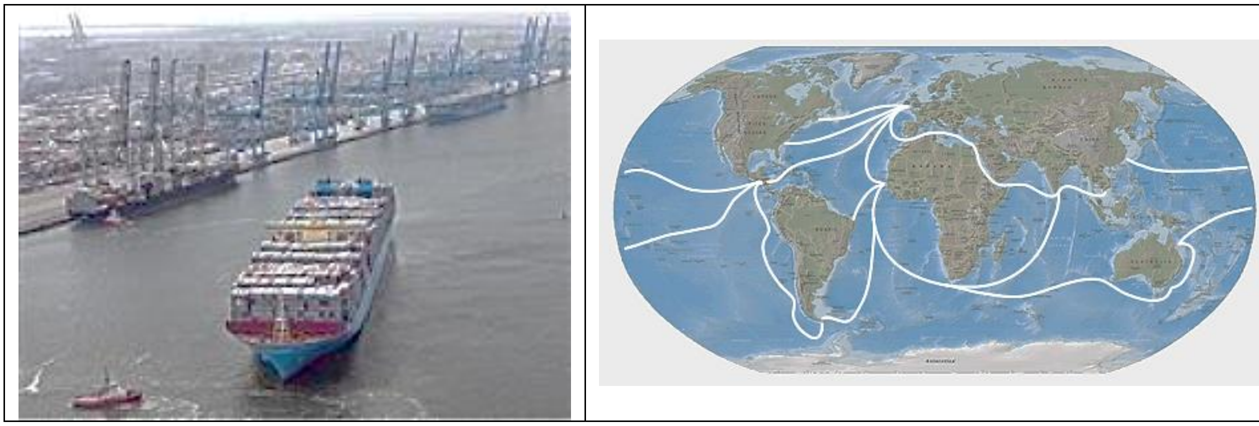


Figure 2.10 High Capacity Ship and Typical Shipping Routes

These developments in air- and sea-based cargo transport systems, coupled with the rapid expansion of commercial bandwidth and the ubiquity of access to data in all geographic regions of the world, will produce more efficient, traceable commercial delivery systems in 2025.

3.0 CONCEPTS AND ENABLERS (TOR TASK 1)

Strategic and expeditionary maneuver are used in various phases of conflict (Figure 3.1). Strategic maneuver occurs in early planning phases prior to the crisis. Expeditionary maneuver occurs during initial entry over the first 30 days, and during the build-up of follow-on forces and sustainment after that.

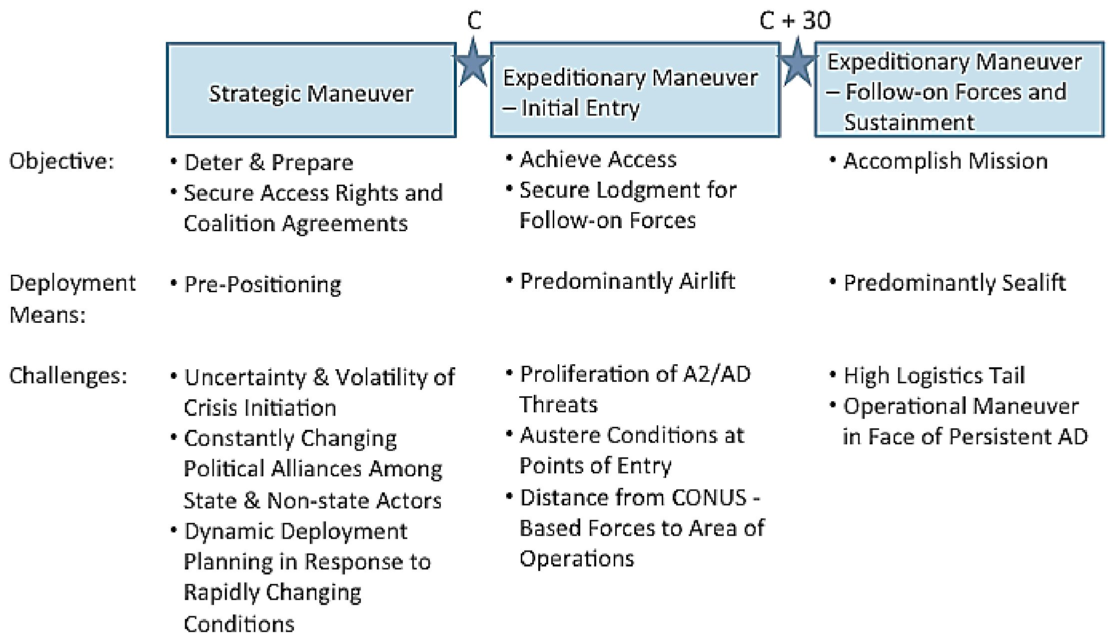


Figure 3.1 Objectives and Challenges for Strategic and Expeditionary Maneuver

The study team identified four advanced concepts to enhance strategic and expeditionary maneuver:

1. Dynamic capability-based deployment planning
2. Synchronized distributed interdependent maneuver
3. Counter-digitization
4. Adaptive logistics support

These concepts affect both strategic and expeditionary maneuver (Figure 3.2), as well as each other, and should be considered constituent aspects of the larger deployment process.

The remainder of this section details the challenges to strategic and expeditionary maneuver that each concept attempts to address, defines each concept, and identifies technology enablers that support each concept.

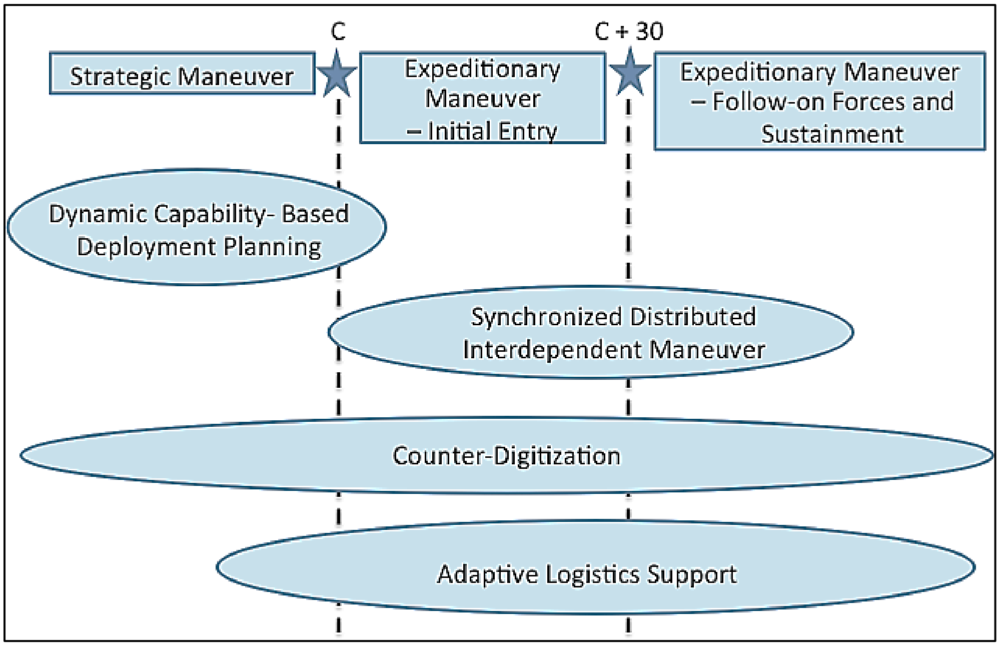


Figure 3.2 Advanced Concepts Cover All Phases of Conflict

3.1 DYNAMIC CAPABILITY BASED DEPLOYMENT PLANNING

3.1.1 CHALLENGES

As part of its data gathering, the study team met with Combatant Commands (CCMDs) and Army Service Component Commands (ASCCs). While discussing the deployment planning process (specifically, between Phases 0 – III), representatives from these headquarters identified a common problem they face: the lack of clarity regarding Army capabilities and the specific deployable components required to generate those capabilities in theater. One example relayed by an interviewee involved an ASCC trying to design a Phase I package, but not having the data to assemble the correct, supportable intelligence system from the Unit Type Code (UTC), nor visibility of the dependencies within a Unit Identifier Code (UIC). Planners contended the reasons for these and similar disconnects had to do with the inherent friction created by a Joint-regulated planning process that relies upon data belonging to each of the Services. As a result, planners operate under Joint business rules which promote the issuance of capabilities-based requirements from CCMDs, but in the execution to fill those requirements, the process is somewhat agnostic about prioritizing capabilities over other considerations. For example, interviewees at USTRANSCOM described how a Time Phased Force Deployment Data (TPFDD) package is processed, and how strategic lift is allocated. From their perspective, the TPFDD presents the lift requirement but does not provide any assistance in managing the presentation of capabilities. Rather, it manages for optimal use of available lift assets. In short, the systems and data are used to optimize the flow but do not appear to be set to optimize capability on the ground as an integral part of that flow.

Subsequent discussions with the Joint Staff and Army Forces Command (FORSCOM), the Army's force provider to CCMDs, confirmed the study team's observations. The lack of clarity around Army capabilities has led to generating sub-optimal force packages. Furthermore, the impediment had been identified for some time, and attempts to correct it have been made. In 2010, the JCS initiated a program to standardize unit personnel descriptions, as well as the allocation of spaces and equipment. That effort, the Global Force Management – Data Initiative (GFM-DI) (Figure 3.3), was intended to build a common framework in which all Services and CCMDs could share data with a level of fidelity that assured capability and skill set requests would be accurately mapped across all Service systems.

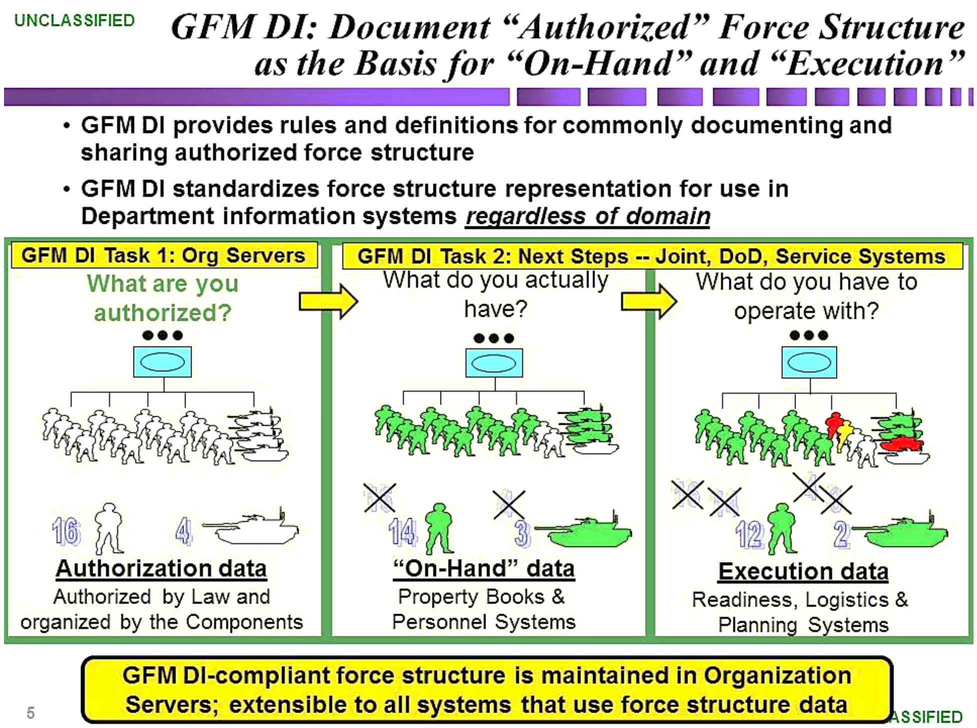


Figure 3.3 Global Force Management – Data Initiative[21]

Unfortunately, GFM-DI has yet to apply the same logic to build an ontology that supports describing capabilities as well as spaces and equipment. Specifically, the catalog needs to enable the entire Joint community to understand the capabilities and dependencies in each Service's table of organization and equipment (TOE), down to the squad, crew, and team level. Without this adjustment, as GFM-DI comes on line, it will be possible to see the unit spaces and equipment, but it won't be possible to extract the capabilities of the unit, nor be assured that all the dependencies enabling that capability are identified.

The planners also expressed a need for analysis support to evaluate potential force packages. A deployment model that evaluates airlift, sealift, and ground transport options could be used to estimate time of arrival for various components. Simulations could evaluate the effectiveness of the force package, and follow-on analyses could then be iterated to optimize the force package. The analysis tools wouldn't need to have the level of detail of major war gaming efforts, nor of

[21]Joint Staff (J-8) GFM DI 101 Briefing (21 November 2013)

TRANSCOM deployment planning tools, to permit planners to explore options before selecting a proposed force package.

3.1.2 CONCEPT

There are two elements to the Dynamic Capability-Based Deployment Planning concept: (1) expanded personnel and equipment databases, and (2) models and simulation for analysis support.

3.1.2.1 DATABASES

GFM-DI standardizes force structure representation for use across DoD information systems. Its data is stored in Service Organizational Servers. The Army Organizational Server (AOS) is administered by HQDA G3 Force Management, and the Army has led other Services in adapting GFMDI formatted force structure data. For example, U.S. Forces Command (FORSCOM) uses AOS data to produce an Army Unit Catalog capable of "shredding" the force structure to the billet level, and "teaming" the billet or echelon to its authorized materiel and personnel. The Catalog also enables searching for specialized personnel skills and/or particular items of materiel needed to support specific missions, such as disaster relief. Additional capabilities are being added to the Catalog, which include command relationships, exact composition of unit derivatives (via Defense Readiness Reporting System-Army), and linkages to force generation cycles.

Several organizations in the Army are involved in GFM-DI, but none have championed the objective of making the Army's data the clearest and easiest to use by the planners at the CCMD and ASCC levels. The study team believes this is an achievable goal. By focusing those organizations with equity in GFM-DI on defining capabilities and mapping dependencies, designers will be able to build an ontology to include those elements within the GFM-DI construct. In doing so, the Catalog would be expanded to address the shortcomings reported to the study team by planners. Specifically, the catalog needs to enable the community to understand the capabilities and dependencies in each TOE organization down to the squad, crew, and team level. The technical composition of the catalog can also be applied to or embedded in the Army Enterprise Resource Planning Systems (ERP) as well as any Army system requiring force structure data.

The study team estimates full implementation of the Catalog for use across the Army could be achieved within 12 months, but that would require senior leader emphasis and resources allocated over and above the two full-time personnel currently producing and fielding the Catalog. For example, FORSCOM could build a prototype mapping, and Program Executive Office Enterprise Information Systems (PEO-EIS) could build the ontology into the servers. Supporting elements would include the Center for Army Analysis (CAA), the Logistics Innovation Agency (LIA), and/or the Surface Deployment and Distribution Command Transportation Engineering Agency (SDDC TEA).

Beyond addressing the needs of deployment planners, the Army will likely find other uses for a database of its detailed capabilities, such as managing capability sets, as well as managing units. Furthermore, the enhanced Catalog will provide more clarity to the Defense Readiness Reporting System (DRRS) data, and the Joint planning process across all phases.

The database may also be expanded to include contractor support data, as well as data on capabilities the COCOM decides to accomplish using contractor personnel vice deploying uniformed service members and/or equipment. Beyond sustainment capabilities (such as base operations and support), the database should be built to reflect the spirit and intent of Operational Contract Support (JCS Pub 4-10), which includes intelligence, communications, and security.

Finally, designers should extend the database to include partner nations and Non-Governmental Organizations (NGOs).

3.1.2.2 MODELS AND SIMULATIONS

Deployment planners relayed their desire for a deployment model that would permit evaluation of arrival times for various components of the proposed force package. This could be as simple as a spreadsheet that uses various rules of thumb to evaluate airlift, sealift, and ground transport options, as well as intermodal transport.

Planners also described a need for simulators that could evaluate the effectiveness of proposed force packages, and that would ensure all the necessary components are included in the package. The simulator would need to present sufficient detail to identify missing components, while also running quickly enough to permit multiple iterations to optimize the package.

3.1.3 ENABLERS

Two enablers support the database enhancement:

1. An expanded Army approach on GFM-DI, to include capability-based mapping and the supporting ontology
2. Pulling together the community of interest and tasking them to produce a prototype mapping of capabilities and the supporting ontology and server instantiation

The modeling and simulation development could be accomplished using emerging software techniques.

3.2 SYNCHRONIZED DISTRIBUTED INTERDEPENDENT MANEUVER

Synchronized Distributed Interdependent Maneuver (SDIM) addresses the challenges facing Joint forces attempting to gain access to an AO in the face of armed opposition with A2/AD capabilities. It also addresses the subsequent operational maneuver to accomplish mission objectives in a persistent AD environment. The main focus of the concept is the unpredictable, initial entry of tailored forces, via multiple penetration points, in order to secure lodgment for the massed entry of reinforcing and follow-on forces. Immediately upon entry, these distributed forces must be able to conduct synchronized and effective operations across a spectrum of scenarios and environments, including urban warfare in mega-cities. With some redesign and development of supporting TTPs, the concept can be implemented within the Army's current force structure. Requisite improvements in mission effectiveness and reductions in lift burden may be rendered by developing near-term technologies, systems, and processes, which could be fielded by 2025. Also, several longer-term enabling capabilities could improve effectiveness beyond 2025. Multiple near-term and longer-term enablers are identified and discussed below. The implementation of SDIM isn't dependent on the adoption of all the enablers; any one, or a combination of several, will enhance the overall effectiveness of SDIM.

3.2.1 CHALLENGES

The JOAC describes the military challenge addressed by SDIM:[22]

> The essential access challenge for future joint forces is to be able to project military force into an operational area and sustain it in the face of armed opposition by increasingly capable enemies.

The Joint Concept for Entry Operations (JCEO) defines capabilities the Army of 2025 must have to operate in complex environments:[23]

> The future Joint Force must be able to enter onto foreign territory and immediately employ capabilities to accomplish assigned missions in the presence of armed opposition, including advanced area denial systems, while overcoming geographic challenges and degraded or austere infrastructure.

SDIM addresses the challenge that predictable points of entry (e.g., airfields, ports) become attractive targets for A2/AD threats, which can destroy or render them unusable until joint forces can secure and reconstitute them. One method to avoid creating this vulnerability would have initial entry forces deploy into austere locations without accessing prepared ports of debarkation (POD). In some scenarios, even if mature PODs are accessible, austere penetration points may be preferred to preserve an element of surprise against hostile forces.

The joint Army–Marine Corps concept for gaining and maintaining access[24] expands on this premise, stating that the Army and Marine Corps must be capable of:

> Conducting simultaneous force projection and sustainment of numerous maneuver units via multiple, distributed, austere and unexpected penetration points and landing zones in order to avoid established defenses, natural obstacles, and the presentation of a concentrated, lucrative target.

Threats to entry operations are exacerbated by the ubiquitous access to information technology, which, in the hands of discerning hostile forces, can provide near-instantaneous networking and information sharing capabilities. The sharing of detection reports from relatively unsophisticated

[22] JOAC, Version 1.0, Department of Defense, 17 January 2012, p. iii
[23] JCEO, Joint Chiefs of Staff, 7 April 2014, p.vi
[24] Gaining and Maintaining Access: An Army-Marine Corps Concept, United States Army and United States Marine Corps, Version 1.0, March 2012, p.7.

threat ISR allows adversaries to concentrate lethal A2/AD capabilities against massed forces attempting entry at a single penetration point.

Lastly, due to the foreseeable, continued growth of mega-cities, any expeditionary force may be required to operate almost immediately in urban areas, including the various layers where the enemy may be engaged: subsurface, surface, elevated (buildings), airspace, and the cyber, communication, and information realms. This introduces the need for initial entry and reinforcing forces to be mission-tailored, trained, and ready for urban operations. For example, lessons learned from the Battle of Sadr City in 2008 identified key factors that led to the success of that operation. The study team believes these factors will continue to be relevant for success in future urban conflict:[25]

- Persistent ISR combined with precision strike
- Armor and engineer equipment for ground maneuver
- Snipers and special operations forces (SOF) as enablers
- Distributed decision-making
- The ability of a force to quickly transition to high-intensity, decentralized, close combat operations

3.2.2 CONCEPT

The keys to SDIM are unpredictability and flexibility. The Army needs to build the means, skills, and knowledge to execute unpredictable initial entry of mission-tailored and mission-capable small units at multiple points. Once deployed, distributed units must be able to conduct synchronized operations to achieve mission objectives. The concept is built upon the following key elements articulated within the JOAC and JCEO:

1. Mission-Tailored, Mission-Capable, Entry Forces: "Conducting joint entry operations requires mission-tailored joint forces that are organized, trained, and equipped with unique capabilities. Mission- tailoring begins with a thorough understanding of the purposes for the operational task of entry that can differ in intent and duration as well as the type and quantity of forces required." (JCEO; p. vii)
2. Unpredictable Maneuver: "The idea is to employ opportunistic, unpredictable maneuver, in and across multiple domains, in conjunction with the ability to attain local superiority at multiple entry points to gain entry and achieve desired objectives." (JCEO; p. vi)
3. Cross Domain Synergy: "Future joint forces will leverage cross-domain synergy—the complementary vice merely additive employment of capabilities in different domains such that each enhances the effectiveness and compensates for the vulnerabilities of the others—to establish superiority in some combination of domains that will provide the freedom of action required by the mission." (JOAC; p. ii)
4. Synchronized Distributed Operations via Decentralized Mission Command:

[25] As captured in Dave Johnson, et al. The 2008 Battle of Sadr City (Santa Monica, CA; Rand: 2011) available at http://www.rand.org/content/dam/rand/pubs/occasional_papers/2011/RAND_OP335.pdf

- "The synergy that is central to this concept will require a high degree of integration and synchronization in planning and execution across domains, not only at the component level, but at lower echelons as well." (JOAC; p. 28)
- "To support high-tempo distributed operations and to cope with a degraded command and control environment, this concept envisions decentralized command and control to the extent possible in both planning and execution. Such mission command enables subordinate commanders to act independently in consonance with the higher commander's intent and effect the necessary cross-domain integration laterally at the required echelon." (JOAC; p. 28)

5. Deception and Confusion: "Maximizing surprise through deception, stealth, and ambiguity, maneuvering through multiple domains during entry presents many potential threats to an adversary, disrupting his decision cycle and exploiting critical vulnerabilities." (JCEO; p. vii)

3.2.3 ENABLERS

A variety of technologies, systems, and processes render SDIM feasible by 2025. Given the time required for a new Program of Record (POR) to reach Initial Operating Capability (IOC) routinely exceeds ten years, the study team focused on those enablers that wouldn't require a new POR to be established. As such, the enablers may be implemented through mature COTS/NDI hardware or software, or through upgrades to current POR systems, or they may fall outside of DoD 5000 Acquisition System procurement.

The following examples of enabling capabilities were developed using the study analysis baseline: SBCT deployment via airlift to an austere AO at 7,000 nautical miles from a CONUS base (see Section 4 for further details).

3.2.3.1 MISSION-TAILORED, MISSION-CAPABLE ENTRY FORCES

Mission tailoring of initial entry and reinforcing entry forces is essential to the SDIM concept. The defining characteristic of these forces is their ability to enter an AO as tactically competent units, i.e., able to operate immediately upon arrival, without relying upon predictable infrastructure/ PODs (such as sea ports or airfields). Since the initial entry operations will be deployed primarily by airlift during the first 30 days of operations, it's necessary to tailor the forces at small unit echelons (company or below), so that a holistic, lethal capability can be delivered with a limited number of C-17 sorties. For example, using our baseline analysis case of an SBCT deployment, it might be desirable in some scenarios to deploy a rifle company from each Infantry Battalion as the initial entry force, and then build up the BCT in phases. However, sub-elements of other SBCT units (e.g., some elements of an engineering company, signals company, and/or military intelligence company) would need to be deployed with the rifle company to provide a holistic and tactically significant capability upon arrival.

Three enablers support mission-tailored, mission-capable entry forces:

1. Dynamic Capability Based Deployment Planning – The rapid deployment planning for this low echelon level of tailoring would require the Dynamic Capability Based Deployment Planning capability discussed above. The desired end state is to have planners at various levels

and echelons of the deployment process work off of a common catalog of capabilities and forces, with the assurance that all supporting elements of any force package are identified. The catalog would have to be designed to share its data with TPFDD creation and the allocation of Unit Line Numbers (ULN) to allow for the deliberate sequencing of capabilities into the AO. As the CCMD provides more clarity to USTRANSCOM about the desired capability sequence, USTRANSCOM could then optimize the lift assets to accomplish the mission.

2. Advanced Weapons – The ability of distributed forces to conduct synchronized and effective operations immediately upon entry across a spectrum of scenarios and environments, including urban warfare in mega-cities, is largely dependent upon the size and composition of the deployed forces and weapons. The lethality that small entry forces require to be mission capable is a function of the specific scenario, joint force composition, and threat capability. The rifle companies in the study's baseline SBCT deployment currently have lethal capabilities against various light, medium, and heavy armor targets, as well as enemy personnel. That lethality is provided by man-portable AGM-148 Javelin lock-on-before launch missiles, light anti-tank weapons, unguided mortars, grenade launchers, machine guns, and rifles. Effective engagement range and targeting precision is limited, however, and combat effectiveness is thus compromised in many A2/AD environments. Adding precision fires/munitions that are effective at current and extended engagement ranges, as well as advanced multi-purpose, scalable effects weapons, would provide operational flexibility and force-multiplier effects that enhance the units' lethality and combat effectiveness. For example, the effectiveness of various precision strike weapons, such as the AGM-148 Javelin, M982 Excalibur artillery projectile, AGM-114 Hellfire missile, Guided Multiple Launch Rocket System (GMLRS), and the Advanced Precision Kill Weapon System (APKWS), has been proven in numerous U.S. combat operations, most recently in Iraq and Afghanistan.

3. Manned/Unmanned Teaming with Semi-Autonomous Lethal UGVs – Semi-autonomous UGVs teamed with manned systems provide the potential for increased lethality and survivability over existing, solely manned vehicles. Teaming also offers a benefit by reducing the lift burden (Figure 3.4). Gains in lethality may be particularly pronounced in mega-city operations, where smaller UGVs would be better for passing through narrow or constricted passages that would serve as ambush locations against larger, manned systems. The lethality benefit would also accrue across the distributed operations of small units, where the UGV teams could disperse over a greater area of operations than manned systems alone.

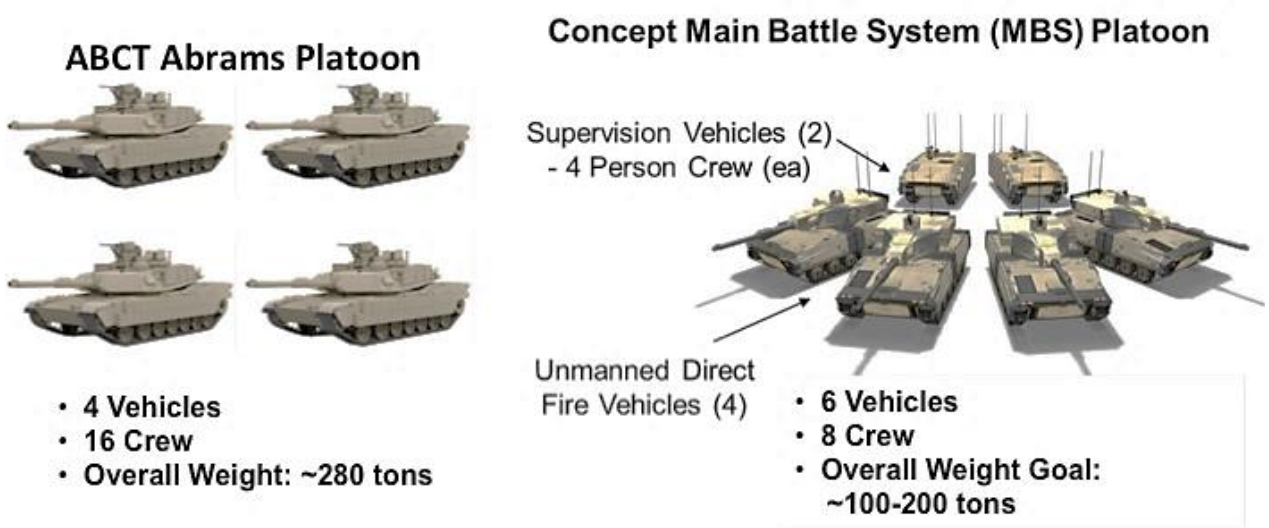


Figure 3.4 Manned/Unmanned Teaming: Semi-Autonomous Lethal UGVs

3.2.3.2 UNPREDICTABLE MANEUVER

The SDIM concept relies upon the ability of Joint forces to gain access to unpredictable points of entry. Once the breach is secured, SDIM becomes contingent upon on the ability of those forces to operate in environments in which mature infrastructure may not be available or accessible, or in which the usurpation of mature infrastructure may not be desirable from an operational perspective. The JOAC articulates this need:

> Some operations to gain access will occur in austere environments lacking the advanced infrastructure typical of modern societies. In the anti-access case in particular, even if the objective area is well-developed in terms of infrastructure, the most desirable approaches may well be austere. In the area-denial case, many conflicts will arise in failed or failing states where infrastructure is lacking. In such cases an advancing force will have no option other than to operate under austere conditions… The ability to operate effectively in such conditions can confer an advantage to an advancing force because it increases operational flexibility by freeing the force from major ports, airfields, and other infrastructure, and thereby also complicates enemy intelligence collection efforts. (JOAC, p. 7)

Inserting forces away from infrastructure, such as airfields and seaports, lays the groundwork for unpredictable maneuver. The study baseline postulated a conflict requiring heavier forces (e.g., than the 82nd Airborne Division) for initial and reinforcing entry. Maneuvering those forces, heavy vehicles, equipment, and support, poses a challenge. Some near-term enablers that can provide the capability include existing unmanned rotorcraft and precision air drop parafoil systems. In the longer term, unmanned vertical systems for Joint Logistics Over-The-Shore (JLOTS) and Mounted Vertical Maneuver (MVM) provide promising capabilities. The advantages to MVM are well defined in the Joint Army/Marine Corp document, "Gaining and Maintaining Access: a Joint Army-Marine Corp Concept:"

> A key enabler of operationally significant entry capability is MVM, which is the maneuver and vertical insertion of medium weight armored forces into areas in close proximity to objectives without the need for fixed airports, airfields, or prepared airheads. By avoiding predictable fixed airfields and airports, MVM increases the number of landing areas available to the land force thereby creating defensive dilemmas for the adversary. But more significantly, vertical maneuver of mounted forces provides the means to rapidly gain positional advantage over the enemy creating and magnifying the effects of surprise. (Army-Marine Corps Concept, p. 10)

The study team believes vertical lift and precision airdrop will remain the key enabler of unpredictable maneuver for the foreseeable future. Several operational and/or technologically mature unmanned vertical systems could be leveraged by the Army to meet near-term cargo delivery to the entry points and/or to support follow-on maneuver within the AO. For example, the K-MAX unmanned rotorcraft was used successfully by the USMC for cargo delivery in Afghanistan. Its maximum payload capacity of 6000 lb. (at sea level) may not be adequate for lift of many Army SBCT or ABCT vehicles, but it could support delivery of some equipment and sustainment supplies, including fuel, water and ammo. These consumables represent over 30% of the tonnage required to deploy an SBCT with 30 days of sustainment. Another option is the USN Fire Scout UAV, which can carry roughly 700 lb. of payload, or the Unmanned Little Bird, which can carry up to 2000 lb.

Another near-term option is the Joint Precision Air Drop System, or JPADS, which uses a GPS-guided cargo parachute to resupply troops by air in a wide variety of terrain, climates, geographically secluded areas, denied areas, and urban terrain. JPADS is a unique resupply capability in that can be dropped from up to 25,000 ft. and then fly itself to a target drop zone on the ground. The resulting vertical and horizontal offsets from the target drop zone result in minimized threat exposure to the aircrew. The Army successfully used 2000-pound JPAD systems in Afghanistan and has purchased 110 of the 10,000 pound systems. They provide enormous operational flexibility to an expeditionary unit. However, they are expensive and require larger economic buys to make the system available for training on deployments.[26] Furthermore, the Army will need to develop better airdrop software.

In the longer term (beyond 2025 for IOC), advanced rotorcraft systems offer great potential to support unpredictable maneuver. The potential for Joint Heavy Lift (JHL) to support Army vertical maneuver operations has been studied and well substantiated.[27] However, budgetary constraints have precluded development. In the meantime, autonomous system technology has matured sufficiently so that unmanned versions of a JHL capability may be considered as a

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[26] See "JPADS: Making Precision Air-Drops a Reality," staff article from Defense Industry Daily, 27 Apr 2014; available at http://www.defenseindustrydaily.com/jpads-making-precision-airdrop-a-reality-0678/

[27] Vergun, David, ARNEWS, "Future vertical lift capability focuses on tech demo," available at http://www.army.mil/article/129233/Future_vertical_lift_capability_focuses_on_tech_demo/; last visited 16 Jan 15. ASB also conducted studies in this area, notably the FY2000 Summer Study Technical and Tactical Opportunities for Revolutionary Advances in Rapidly Deployable Joint Ground Forces in the 2015-2025 Era. Volume II: Operations Panel Report (April 2001), and FY2012-2011 Summer Study Strengthening Sustainability and Resiliency of a Future Force, Phase I Report (March 2011)

baseline for a future JHL-like system. An unmanned sky crane system for JLOTS and MVM capable of carrying 20 to 30 short tons would offer significant operational benefit to SDIM and could be developed and produced at lower acquisition and operations cost than previously studied manned systems. The unmanned sky crane could utilize many of the technologies that will be demonstrated on the Joint Multi-Role Technology Demonstrator (JMR-TD) for the Future Vertical Lift (FVL) program.

3.2.3.3 CROSS-DOMAIN SYNERGY

Cross-domain synergy, the central theme of the JOAC, refers to the integration of all domains – air, land, sea, space and cyberspace – at lower force echelons, such that temporal superiority in any one domain can be utilized to gain operational advantage over the hostile forces. The integration of all domain capabilities at low echelons is key to the concept:

> This concept envisions a greater degree of integration of actions and capabilities across domains and at lower echelons than ever before. Embracing cross-domain synergy at increasingly lower levels will be essential to generating the tempo that is often critical to exploiting fleeting local opportunities for disrupting the enemy system. This concept also envisions the fuller and more flexible integration of space and cyberspace operations into the traditional air-sea-land battlespace than ever before. (JOAC, page 16)

For the Army, cross-domain synergy demands tactically significant space and cyber capabilities that are well integrated into, and exploited by, low echelon units. Once accomplished, small units at the tactical edge will fully utilize non-organic ISR information and be able to conduct counter-digitization operations.

Counter-digitization is discussed in detail below (Section 3.3). For cross-domain synergy to be effectively implemented, mission-tailored entry and reinforcing forces must possess both the defensive and offensive capabilities of counter-digitization. It is also necessary to ensure that the effects of counter-digitization, both offensive and defensive, are considered as early as possible in mission planning, since in some cases (e.g., mega-cities with substantial communications and other infrastructure), counter-digitization is likely to play a much larger role than in austere environments lacking infrastructure.

It should be noted that, to varying degrees, counter-digitization (both offensive and defensive) may be executed remotely from the AO. Thus, "deploying" effective counter-digitization mechanisms may not require in-area resources, lift, sustainment, etc. For example, scanning a network for vulnerabilities and pinpointing specific resources for attack can be done remotely, as long as connectivity to the network exists.

3.2.3.4 SYNCHRONIZED DISTRIBUTED OPERATIONS VIA DECENTRALIZED MISSION COMMAND

Immediately upon entering the AO through multiple points, distributed small units must be capable of operating independently by means of decentralized command and control. Both the deployment into theater and subsequent maneuver and movement of the distributed units must be integrated and well synchronized to achieve a unified operational objective. Synchronization and integration rely upon the abilities of distributed units to communicate among themselves and with their TOC. However, the burden placed on airlift assets to transport the fixed infrastructure of traditional SATCOM, ground stations, and the associated power generation systems, may preclude the availability of robust communications during early entry phases.

Three enablers meet the requirements of synchronized distributed operations:

1. UAV Aerial Layer for Communications – An aerial communications layer provided by small UAVs operating at medium altitudes could provide the high-bandwidth backbone needed for enhanced communication among small units. Such a layer could also support the download capacity required for actionable ISR and SA to be displayed on smart devices to small units and dismounted soldiers. Moreover, in urban environments, the aerial layer will be necessary to provide the requisite persistent positioning, navigation, and timing (PNT) that requires line-of-sight. A UAV aerial layer for battlefield communications has been assessed and demonstrated on several programs. The Initial Capabilities Document (ICD) for the Joint Aerial Layer Network (JALN) program, approved in October 2009, defined the following capabilities:

   - Support net-centric, C2 and Battlespace Awareness requirements
   - Integrate with space and surface layers
   - Increase communications access for the joint force at all levels
   - Enable on-the-move (OTM) and over-the-horizon (OTH) / beyond line of sight (BLOS) communications
   - Provide “mission persistent” connectivity as specified by the commander
   - Support strike, mobility, special operations, C2, and ISR missions

   Several programs have demonstrated aerial layer capabilities with prototype hardware. Of note, a WIN-T tactical increment 3 (Inc3) airborne layer with a High-band Network Waveform (HNW) LOS radio extended the range of the WIN-T ground LOS high data rate network. The range extension of an SRW network (lower TI, vehicle/dismounts) has also been demonstrated using an Aerostat platform, as well as tactical voice networks (CNR, SINCGARS) using small UAVs (e.g., Shadow, Gray Eagle).

   To overcome the challenge of data transmission in remote areas, DARPA’s Mobile Hotspots program intends to develop and demonstrate a scalable, mobile, millimeter-wave communications backbone with the capacity and range needed to connect dismounted warfighters to their command centers. The backbone should also provide reliable end-to-end data delivery between hotspots, as well as from ISR sources and command centers. The program envisions air, mobile and fixed assets, most of which are organic to the deployed unit, that provide a gigabit-per-second tactical millimeter-wave backbone network extending to the lowest-echelon warfighters.

Several operational and near term unmanned systems could provide the UAV platform for the aerial layer. Among these are the K-MAX and Fire Scout rotorcraft systems, and the Gray Eagle fixed-wing UAV. Other advanced technology systems offer the promise for vertical systems with an endurance of 24 hours, including the A-160 optimal speed rotor technology.

The Army may also be able to leverage aerial layers developed by commercial companies, such as Google's Project Loon balloons, which float in the stratosphere, twice as high as aircraft and global weather conditions. People can connect to the balloon network using a special Internet antenna. The system has been demonstrated in New Zealand. Google also purchased a company, Titan, which makes high altitude UAVs.

The Aerial layer can also provide reach-back to CONUS so that staff elements are not required to be deployed. The 82nd Airborne Division has been able to reduce its staff headcount in Afghanistan by exploiting high-bandwidth communications in theater and connecting sensors and remote mission command systems to staff located at Ft. Bragg. Thus, the 82nd Airborne Division tailors its deployed command and control elements in the AO based upon communication assets that are available.

2. Mission Command on the Move – Small units must be capable of mission command on the move (MCOM) to take and maintain initiative, and to exploit temporary overmatch in any domain, while still maintaining synchronization with adjacent distributed forces. Small unit MCOM can be supported by an aerial layer providing the bandwidth for downloading ISR and SA to mounted and dismounted soldiers via smart devices. Advances in commercial smart devices and information displays provide great potential for implementation of this capability. In providing this capability, the technologies selected must confront the traditional concerns over device authentication (making sure that only authorized devices are communicating) and communications security (making sure that the data streams are encrypted and retain data integrity).

3. Cloud Computing – Commercial entities, such as Amazon, have developed global infrastructures that allow the rapid instantiation of servers to accomplish specific tasks, in a secure environment, on the fly, in a distributed mode that allows organizations to rapidly expand and contract their computational base. Using this approach, tasks can be done in a parallel fashion, using large data sets, and enabling solutions to be quickly determined. When combined with the emerging communications infrastructure, this would further enhance mission control without increasing the deployed footprint.

One final note regarding bandwidth. There are pervasive bandwidth constraints in the CENTCOM AO, particularly in Afghanistan, and this may be the case in other AOs as well. Over the course of its analyses, the study team did not become aware of any potential constraints regarding bandwidth that would negate the advanced concepts outright. Because the advanced concepts and their associated enablers are submitted with the intent that the Army will conduct further experimentation and analysis, the study team assumed specific bandwidth requirements would be determined as part of that process. In particular, the study team foresees potential challenges maintaining situational awareness under SDIM because small, interdependent units that are widely dispersed will create different bandwidth requirements than those flowing from a more centralized structure.

3.2.3.5 DECEPTION OPERATIONS

The JCEO provides the following role for deception, stealth and ambiguity in entry operations:

> The Joint Force will maximize surprise through deception, stealth, and ambiguity to counter adversary terrestrial, aerial, and space-based ISR and complicate targeting. One method the Joint Force may use to confound the enemy is to create either a dearth or overabundance of targets for the enemy to process. Social media and other cyber-enabled deception methods may be valuable contributors to gaining surprise. Where surprise is not possible due to the nature of the operating area or the duration of the operation, the Joint Force will seek to overwhelm the enemy's targeting capability. This could be done, for example, through a combination of cyberspace efforts and the use of numerous autonomous decoys employed in one or more of the other domains. The radar and electromagnetic spectrum (EMS) signatures of these systems should match that of the system they are simulating to create more targets than the enemy can process or engage. Additionally, these devices could possess the ability to attack targets autonomously as they present themselves through the use of various electronic counter countermeasures (ECCM) and seek out critical targets for attack. (JCEO, p. 12)

Two enablers support deception operations:

1. Small Decoy UAVs – Small UAVs can play a vital role in deceiving and confusing threat ISR during SDIM operations. The JCEO envisions just such a role for UAVs:

   > A variety of unmanned options can be used to deceive or operate in the portion of the operational area that presents the most risk in order to saturate enemy defenses. Unmanned decoys can aid in drawing adversary fire away from critical manned assets, or in deceiving the adversary as to the critical point of attack. Unmanned systems working in concert with manned systems can be critical in overwhelming enemy defensive sensors. (JCEO, p. 21)

   A number of existing or near-term small UAVs could potentially provide the platform for such a capability. The effectiveness of the system would be dependent on the decoy payload and integration of the payload with the UAV.

2. Counter-Digitization – The counter-digitization concepts detailed in section 3.3 below provide multiple avenues for disrupting and confusing adversaries, which would enhance the success of entry operations. Simply put, wherever the opposing force relies on communications, data storage and processing, or other electronic resources, cyber offensive capabilities may be able to deny the use of those resources, or may be able to implant misinformation so that the opposing force relies upon bad data. Where the entry force relies

on communications, data storage and processing, or other electronic resources, cyber defensive capabilities should ensure such resources are not denied, and that the information they supply has not had its integrity or authenticity compromised.

3.3 COUNTER-DIGITIZATION

Throughout the latter half of the 20th Century, a tension developed between electronic systems designed to counter the effects of weapons and sensor technologies, and systems designed to counter those counters. As so-called electronic countermeasures (ECMs) emerged, so too emerged electronic counter-countermeasures (ECCMs). This dynamic competition—driven largely by the United States and the Soviet Union—spawned new generations of ever more capable ECMs and ECCMs, and the maturation of electronic warfare as a legitimate, if not absolutely essential, element of modern warfare.

A new, but similar competition is beginning to emerge in the digital realm. This is most obvious in the area of cyber warfare, where the tension between offensive and defensive measures is familiar to anyone who has fallen victim to a computer virus or unauthorized hacking. But the competition transcends cyber or electronic warfare alone. As 21st Century armies, especially the U.S. Army, become more reliant on systems that embed digital functionality, they become more vulnerable to new threats against those systems. Software, for example, can be exploited to subvert digital functionality. Hardware, too, can be exploited in a manner that disrupts or degrades—e.g., by damaging or destroying micro-circuits. And as digital systems increasingly connect to networks through wireless means, users are increasingly at risk of software and hardware attacks through remote channels. This creates a critical need for the U.S. Army to reduce digital vulnerabilities going forward. But it also creates a window of opportunity for the Army to achieve technical overmatch and operational advantage against digitally-armed nation- and non-nation-state adversaries.

In the same way that "Digitization" changed the trajectory of the Army in the 1990s, we believe that "Counter-Digitization" will have a similar effect in the 2020s. Technical trends indicate the continued evolution of a digital world, one in which it will be difficult, if not impossible, to maintain an "analog stance" on anything. Because adversaries will also seek to control the digital high ground, it is critical that the Army beats others to the punch and maintains its position as the world's preeminent 21st Century ground force, capable of harnessing the enormous advantages of the digital revolution while simultaneously denying others the same. The Counter-Digitization concept seeks to position the Army to do just that.

3.3.1 CHALLENGES

The JOAC recognizes "…the emergence of space and cyberspace as contested domains" in a future joint operating environment characterized by "emerging antiaccess [sic] and area-denial security challenges." In such an environment, U.S. reliance on digital systems creates potential vulnerabilities across all phases of strategic and expeditionary maneuver.

Many associate these vulnerabilities with cyber-attacks that can deny or degrade network access, which is crucial to effective command, control, and communications. The concern extends to logistics operations in all conflict phases, including pre-crisis positioning. Digital vulnerabilities can give rise to multiple avenues of attack, ranging from denial of service at the network or application level, to disabling any asset connected to the network, to seizing control of assets, and possibly destroying critical components in those assets, such as fire control systems or rotating machinery. While it is common to associate digital assets with computers, these assets include programmable logic controllers embedded in weapons systems and sensors. By 2025, the means to exploit such vulnerabilities will surely be more mature. The Defense Science Board has already cited the relative ease with which "Red Teams have disrupted U.S. forces in exercises using exploits available on the Internet." [28]

For these and other reasons, the key challenges associated with the Counter-Digitization concept are twofold: (1) mitigating digital vulnerabilities across all phases of strategic and expeditionary maneuver, owing to U.S. reliance on digital systems; and (2) exploiting similar vulnerabilities owing to adversary reliance on the same. Of course, meeting these challenges effectively requires more than just technology alone.

3.3.2 CONCEPT

Counter-Digitization harnesses the full potential of offensive and defensive means to exploit an adversary's digital hardware, software, and gateways while securing your own. It involves far more than simply securing networks for assured communications or applying electronic countermeasures or counter-countermeasures against selected targets. The Counter-Digitization concept entails a new approach to combined arms warfare, rather, one in which kinetic, electronic, and cyber warfare are integrated seamlessly in all phases of planning and execution. Since programmable logic devices exist throughout the battlespace (devices on weapons system, computers, servers, etc.), seamless integration is crucial. Contrast this to current approaches to combined arms, which tend to treat each of these as interrelated, yet distinct. The study team believes that the seamless integration embodied in the Counter-Digitization concept has potential game-changing ramifications for future warfare that must not be overlooked or ignored. It is important today, but it will be crucial in 2025 and beyond.

Counter-Digitization is consistent with the Army's emerging doctrine of Cyber Electromagnetic Activities (CEMA). These are defined as "activities leveraged to seize, retain, and exploit an advantage over adversaries and enemies in both cyberspace and the electromagnetic spectrum, while simultaneously denying and degrading adversary and enemy use of the same and protecting the mission command system."[29] To enable these activities, CEMA integrates and synchronizes cyberspace operations with electronic warfare and spectrum management operations. Organizationally, a CEMA element is organic to brigade, division, corps, and theater Army staffs.[30]

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[28] See "Memorandum to the Chairman, Defense Science Board," dated October 10, 2012, contained within Department of Defense, *Defense Science Board Task Force Report: Resilient Military Systems and the Advanced Cyber Threat*, January 2013.

[29] Department of the Army, *Cyber Electromagnetic Activities*, FM 3-38, February 2014. See also Department of the Army, *Unified Land Operations*, ADRP 3-0; and BG Wayne W. Grigsby Jr., COL J. Garrett Howard, Tony McNeill and LTC Gregg Beuhler, "CEMA: A Key to Success in Unified Land Operations,' *ARMY Magazine*, June 2012, pp. 43-46.

[30] Ibid., p. 2-2.

But while consistent with CEMA, Counter-Digitization extends the element to echelons lower in the organization than brigade—e.g., company level—in order to more effectively hold at risk *all* of an adversary's digital systems through coordinated combined arms engagements. Imagine a fire team confronting an adversary with hand-held devices utilizing commercial services for situational awareness, or a forward operating base being surveilled by an unmanned aerial vehicle that an adversary is using to transmit real-time targeting data. Having the capability to attack those systems at the point of engagement—through kinetic or digital means—would be critical to eliminating those threats in real time. In general, the study team believes that creating such an integrated warfare capability at lower echelons would have far more impact than creating it at higher echelons alone.

Counter-Digitization is also consistent with the JOAC, which, among other things, envisions future Joint forces that leverage cross-domain synergy. The idea that cross-domain synergy must be embraced at lower levels of the military organization is central to the Counter-Digitization concept. For the Army, this implies a need to develop and grow a capability within the Brigade Combat Team (BCT) to integrate kinetic, electronic, and cyber warfare effects. The study team believes the Army can best fulfill the JOAC vision and create the conditions under which synergy can emerge by making the organic capability resident and robust at lower echelons within the BCT, and not merely provided as an overlay from higher headquarters. Following this approach, the study team believes the related challenges of mitigating friendly digital vulnerabilities, while exploiting adversarial ones, can be achieved for 2025 and beyond.

3.3.3 ENABLERS

Six enablers support Counter-Digitization. Insofar as this concept integrates kinetic, cyber, and electronic warfare effects, some of these enablers employ familiar terms that are common to those areas:

3.3.3.1 COUNTER-NAVIGATION TECHNOLOGIES

Counter navigation technologies deny (through jamming) access to signals from off-board navigation platforms. They also disrupt (through electronic and other means) the proper functioning of on-board navigational systems, and can spoof navigational systems with corrupt information to degrade their accuracy and effectiveness.[31]

3.3.3.2 COUNTER COMMAND AND CONTROL

Counter Command and Control (counter C2) technologies seek to deny, disrupt, or degrade the myriad functions normally associated with commanding and controlling military forces. In many cases, counter C2 techniques exploit vulnerabilities in the information systems used to effect command and control. In the digital age, such vulnerabilities are not always obvious. For example, Figure 3.5 shows the result of a simple software modification that changed the logic in a cellular phone, disabling the protective mechanism that prevents battery overheating. The result speaks for itself, and illustrates how digital systems may be damaged or destroyed by means other than

[31] See, e.g., John S. Warner and Roger G. Johnson, *GPS Spoofing Countermeasures*, Homeland Security Journal, 2003.

kinetic. Needless to say, simple cell phones are not the only systems that may be corrupted through non-kinetic means. Many C2 systems, designed without sophisticated digital adversaries in mind, share these potential vulnerabilities.

Figure 3.5 Simple Attack on Cell Phone Software[32]

3.3.3.3 DIGITAL RADIO FREQUENCY MEMORY

Digital Radio Frequency Memory (DRFM) technologies—among other things, designed to replicate and re-transmit RF signals using digital means—have broad applications in electronic warfare, and numerous potential applications in the integrated warfighting functions associated with Counter-Digitization.

3.3.3.4 DIRECTED ENERGY

Directed-energy technologies have matured to the point where many military applications are feasible in the short term, such as solid-state laser systems for air and missile defense, or laser communication systems. By virtue of their electronic designs, however, it has long been recognized that digital systems are vulnerable to being denied, degraded, disrupted, or destroyed by directed energy weapons, especially high-power microwave (HPM) systems. Such systems also have the potential to "dial up" effects short of outright destruction, where attribution may be undesired and unavoidable. At the same time, HPM systems have the potential for "fratricide," in that friendly digital devices in the near proximity of HPM may not be able to escape their effects. In the Counter-Digitization concept, therefore, it will become important to harden U.S. systems against HPM weapons—especially over the long term. This is a prudent measure anyway, as HPMs become more readily available in the international defense market and in the inventories of potential adversaries. In short, the study team believes HPMs have matured to the point where they can and will play a significant role on the battlefield, and they should be an essential element in the force of 2025 and beyond.

3.3.3.5 ELECTRONIC BATTLE DAMAGE ASSESSMENT

Understanding how to assess electronic battle damage to digital systems is a key enabler to exploiting advances in DE weapons, especially HPM systems. Among other things, "eBDA" facilitates mission planning for offensive operations, where a range of effects short of destruction

[32] Ibid.

are desired, as well as defensive recovery from adversarial attack. Among the Counter-Digitization enablers, eBDA may be the most immature; although sophisticated eBDA is likely not required by 2025, it could be essential to Counter-Digitization efforts over the long term. Hence, timely and sustained investment in this area is prudent.

3.3.3.6 THE "INTERNET OF THINGS"

The "Internet of Things" (IOT) refers to the trend of connecting all electronic devices to the Internet, as well as to each other.[33] In principle, the IOT brings enormous advantages to military organizations, especially in logistics functions where the availability and quality of information creates enormous efficiencies. But the IOT can also create new dependencies and vulnerabilities to be mitigated (or potentially exploited).[34] In the context of a military unit, the IOT includes embedded programmable logic devices in weapons systems and sensors, and thus touches all aspects of a BCT's assets and activities. As a result, improving authentication and encryption for connection to weapons systems will be key in order to exploit the IOT most effectively. However, we should recognize that understanding how to utilize the IOT within the Counter-Digitization concept may require a new security paradigm which addresses all aspects of security (confidentiality, integrity and availability of data). Such devices must be able to prove they are legitimate and authorized to communicate, and that their communications are encrypted and secured against unauthorized alteration. Achieving these goals is difficult in a commercial enterprise, very difficult on the internet, and promises to be exceptionally difficult in an IOT context.

3.4 ADAPTIVE LOGISTICS SUPPORT

The burden of sustaining the maneuver force poses one of the greater challenges for strategic and expeditionary maneuver. For example, a 30-day supply of water and fuel account for 36-45% of BCT tonnage. The burden can only be alleviated by reducing the distance over which supplies and materiel must travel, and/or by reducing the amount of supplies and materiel necessary to support forward-deployed forces.

3.4.1 CHALLENGES

The study team focused on three challenges that affect logistics support:

1. Limited strategic air and sea lift capacity
2. Consumables demand a significant fraction of lift, especially fuel and water
3. Weight (tonnage) of deployable communications infrastructure

The US Air Force has 187 C-17 aircraft in the active component, plus 12 in the Air National Guard and 14 in the Air Force Reserve, for a total of 213 aircraft. A portion of the fleet is allocated to

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[33] See Jacob Morgan, "A Simple Explanation of the Internet of Things," Forbes: http://onforb.es/RBpX8Z, 13 May 2014.
[34] See, for example, *Tracking and Hacking* published by the Office of Sen. Edward J. Markey, available at http://www.markey.senate.gov/imo/media/doc/2015-02-06_MarkeyReport-Tracking_Hacking_CarSecurity%202.pdf

accompany the President on domestic and foreign travel. The remaining aircraft must support all military requirements worldwide, including humanitarian assistance.

Consumable supplies take a significant portion of lift capacity, often leading planners and logisticians to have to make trade-offs in deploying the BCT package. For example, the additional burden placed on airlift assets to transport communications infrastructure (SATCOM, ground stations, associated power generation systems, etc.) may preclude the availability of robust communications during early entry phases.

3.4.2 CONCEPT

There are four elements in the Adaptive Logistics Support concept:

1. Expand Operational Contract Support
2. Reduce/Source Consumables
3. Exploit Commercial Transport
4. Exploit Commercial Communications

3.4.2.1 OPERATIONAL CONTRACT SUPPORT (OCS) EXPANSION

Over the past several conflicts, the USG has made extensive use of contractors in AOs to provide a wide range of services and facilities. The publication of JCS Pub 4-10[35] identifies a range of services, from traditional sustainment, to non-logistics support (such as intelligence, communications, and security), that will be considered as areas to employ contractors instead of deploying uniformed forces. Thus, the use of contractors as an alternative to uniformed military personnel will be an enduring option for 2025 and beyond.

Because it has multiple executive agency responsibilities in any AO, the Army should consider OCS as one tool to satisfy those responsibilities. Successful execution of OCS requires prior planning at all levels, and for all Phases of the conflict. To achieve this level of coordination, the Army could organize the Army Contingency Contacting Command specifically to accomplish requirements in the AO by utilizing OCS tools and techniques. The Army should also look across functions and develop organizations and training specific to contract personnel, recognizing the importance and pervasiveness of contract support in the battle space, and behind the battle space. Finally, the study team endorses the findings and recommendations of the 2007 Gansler Commission report,[36] the adoption of which would facilitate the execution of OCS.

3.4.2.2 REDUCE/SOURCE CONSUMABLES

Given the limitations of the current fiscal environment and the likelihood that no significant new equipment will be fielded between now and 2025, the Army needs to review its current equipment and determine how it can be made more efficient to reduce the sustainment burden. For example, the Army could review the mobility suite on the M1 tank. By considering more

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[35] Joint Publication 4-10: Operational Contract Support, Joint Chiefs of Staff, 16 July 2014.

[36] Commission on Army Acquisition and Program Management in Expeditionary Operations (31 October 2007). "Urgent Reform Required: Army Expeditionary Contracting". Department of the Army.

efficient engine and drive train options, the fuel requirement for an ABCT could be reduced by as much as 20%. Since fuel is the predominant consumable, this would help to reduce the demand for lift in the expeditionary phase of the operation. This type of review could be replicated for other systems, where the standard would be to apply sustainment engineering to platforms with the goal of reducing consumption. Thus, enterprise-wide, the over-arching objective would be to reduce the demand for lift.

Another example the study team explored involved identifying known, US-associated bottling facilities that would be capable of producing acceptable potable water locally, thus reducing strategic lift requirements. Using Google Earth, the study team found that there are over 200 Coca Cola bottling plants around the world, with locations in most countries. If contracting these facilities proves to be feasible under the OCS construct, then the sustainment lift requirement for the first 30 days could be reduced by 10%.

3.4.2.3 EXPLOIT COMMERCIAL TRANSPORT

The Army might make good use of two trends in the commercial transportation sector (discussed in Section 2.2 above): the use of 777/787 belly cargo, and the emergence of new trade routes for container ships.

The use of 777/787 aircraft will affect the cargo component of the CRAF. Historically, CRAF has provided DoD with both passenger and freight aircraft, based on the composition of the commercial fleets. With the realization that a 777/787 aircraft is 30% more fuel efficient than earlier aircraft, and that these aircraft can carry 100,000 pounds of cargo in addition to a full passenger load, air operators are reshaping their fleets. Specifically, some airlines are taking older freighters out of service and scrapping them. Thus, the Army needs to assess how it will use these emerging capabilities. For example, a unit that is going to deploy on a 777/787 should plan to take advantage of the 100,000 pounds of belly cargo to move unit impedimenta and mission equipment, as opposed to using a DoD strategic asset (C-5 or C-17). Any cargo capacity that the unit does not use should be used for sustainment flow. The Army should encourage DoD to review the CRAF construct to incentivize all carriers to move to the more efficient and effective aircraft.

The second trend, new trade routes that are being developed to take advantage of the larger containerships, presents a new option for supplying deployed forces. In the past, DoD has built prepositioning afloat unit sets and sustainment stocks on dedicated ships, which have served well. However, ships on these routes, whether travelling North/South or East/West, would rarely operate at full capacity. Commercial data indicates that the norm will be around a 75% load factor. That presents an opportunity for improvement. Specifically, by buying some number of slots to maintain a virtual inventory of non-lethal sustainment stocks (food, fuel, water, construction materials) the study team postulates that the Army would be able to position 50 to 100 containers no more than 5 days out from any regional crisis. Such an operation would require managing the containers within a CCOCOM's AO using ships under both US and foreign flags, as well as determining whether containers should be staged in specific ports or kept afloat. To promote a whole government approach across all phases of combat, stocks nearing the expiration of shelf lives could be distributed by USAID. If a Humanitarian Assistance Disaster Relief (HADR) mission occurred, the CCMD would have the option to provide aid quickly to the affected country team with a minimal footprint. It would also be possible to coordinate this operation with the Logistics Civil Augmentation Program (LogCAP) and utilize LogCAP providers to manage and execute the shelf cycle. Organizationally, the Army Materiel Command (AMC) has all of the command relationships to accomplish this operation

3.4.2.4 EXPLOIT COMMERCIAL COMMUNICATIONS

Commercially available smart phones and other devices are being used to display critical information that may be exploited to enhance decision making and enable mission command. Globalized, commercial cell technology will continue to vastly outpace DoD mobile terrestrial radios as the world approaches one phone for every human being. The Army might leverage this technology to enable powerful new mission command capabilities as applications within these devices, since they already contain high-performing CPUs, sensors, and multi-waveform/band radios. New innovations, such as mesh networking, are constantly being produced for these prolific devices.[37] For example, the JOLTED TACTICS ACTD demonstrated a secure 4G LTE network for tactical operations with non-developmental items at a Network Integration Evaluation (NIE) exercise. The exercise used Android tablets and phones with Army mission command software,[38] integrating commercial and government off-the-shelf (COTS/GOTS) technology to address military requirements. The use of 4th Generation (4G) cellphone technology allowed warfighters to access and share critical mission data, regardless of where they were operating. In addition, significant increases in data rates enabled the use of full-motion video, imagery, and other intelligence products.

Assuming every country in the world will support 5G technology in the next decade, the ability to exploit existing commercial communications will allow warfighters to “plug-in” to a host network anywhere in the world. An expeditionary Army will be able to exploit the ubiquity of the 5G infrastructure for both C2 and counter-digitization. Thus, the Army should investigate how it can leverage and interface commercial communication networks.

3.4.3 ENABLERS

The study team identified seven enablers for adaptive logistic support, each of which focused on reducing the distance over which supplies and materials must travel, or reducing the amount of supplies and materiel necessary to support forward-deployed forces.

3.4.3.1 IMPROVED PLANNING MODELS

As described in Section 3.1 above, logistics planners require models that include sustainment planning factors to estimate the amount of materiel needed to sustain the force. Deployment models will further optimize planning for force sustainment. To ensure reliable results, planning factors should be reviewed to ensure sustainment can be broken down to the same level of

[37] For example, see the goTenna networking module at http://gotenna.com/

[38] Documented by John Andrew Hamilton in “Bold Quest Test Ups Ante at NIE with JOLTED TACTICS Test” at: http://www.army.mil/article/127228/Bold_Quest_test_ups_ante_at_NIE_with_JOLTED_TACTICS_test/

granularity as the force package. The models should take advantage of the rich data environment, tools, and techniques used in "big data" to analyze massive data sets.

3.4.3.2 NEW PROCUREMENT PARADIGMS

The Army in expeditionary maneuver will deploy to new and unfamiliar locations, and all equipment and consumables must be taken upon debarkation, or be pre-prepositioned. Water, food and ammunition make up a significant portion of the sustainment burden, with water dominating the load capacity for deployment to arid environments. To provide the expeditionary force of 2025 with the supplies it needs while decreasing the demand on airlift, Army procurement procedures must be executable at the pace of expeditionary maneuver. In some cases, this will require long-term planning. For example, the study team believes the Army should contract with bottling plants now to reserve plant capacity and to establish a commitment for converting the plants to bottled water production when a conflict arises. The contract should be win-win for both parties, not written on an as-needed basis, but rather, as a specific, sustainable, concrete requirement for reserved plant capacity. Recognizing the Army will need to shift funds to establish these relationships, the study team believes assistance from the State Department would help to identify the right plant locations throughout the world. A shared operation with the State Department could also alleviate some of the budgetary cost.

In other cases, procurement at the pace of expeditionary maneuver may not allow for planning, and may require procurement decisions to be made in near real-time response to events on the ground. Recognizing that there is a tendency to contract strictly according to previous procedures, and the contracting process is risk adverse, the study team believes the current process is too slow. Therefore, the study team recommends that Army leadership issue a new vision, mission statement, and procedure that the procurement process supporting expeditionary forces must proceed at the pace of the expeditionary maneuver. To that end, certain procurement practices of the past should be reviewed, modified, and/or eliminated, because the procurement process has become burdened with redundancy, over-regulation, and delays in making decisions.

While the study team does not see a need for wholesale changes to procurement law or regulation, it strongly believes Army leadership should instill in acquisition personnel the idea that, when dealing with expeditionary forces, reasonable and prudent risk-taking will be both condoned and preferred. Building confidence in the Army's acquisition and contracting leadership around the issue of risk-taking will significantly enable the workforce to obtain goods and services in a timely manner. The changes needed will come about when Army leadership demonstrates that responsible individuals making high-risk decisions in the Army's best interest will be valued, even if some of these decisions produce less than desirable outcomes. In short, mistakes will happen, but so long as there is no negligence or criminal intent, acquisition personnel should be allowed to develop an informed and creative decision-making process that includes an element of risk. For example, current public law favors full and open competition as a matter of policy. The intent is to open public contracting to foster competition and reduce costs. This law has proven successful and the US Government has benefited by paying a lower price for the same value. There are, however, notable exceptions to the law requiring competition, and contracting officers can use these (Figure 3.6) under a properly executed document called Determination and Finding (D&F)

to award other than competitive contracts when circumstances dictate. The recommendation is to empower those procurement officials vested with the authority to commit US funds, and to promote logical and informed decisions by contracting officials for supplies and services which are required to support the greater Army operational objectives.

Federal Acquisition Regulation (FAR) 41U.S.C. 3304 and 10 U.S.C 2304 (FAR 6.301) allows for exceptions to full and open competition if there is:

- Only **one** responsible source (FAR 6.302-1)
- **Unusual and compelling urgency** (FAR 6.302-2)
- Industrial mobilization, engineering development or research capability (FAR 6.302-3); **maintain industrial base**
- **International agreement** (FAR 6.302-4)
- Authorized or required by statute (FAR 6.302-5)
- **National security** (FAR 6.302-6)
- Public interest (FAR 6.302-7)
- **Contract modifications** as part of the scope and terms of an **existing** contract
- Interagency agreements
- Orders placed under **requirements contracts or definite-quantity** contracts
- Procurements under set-aside programs such as the 8(a) program

Figure 3.6 Exceptions to Full and Open Competition

The dynamic nature of future expeditionary maneuver could make use of some of the exceptions already listed in the FAR. To guard against abuse of the system, closer management of the procurement process would discourage fraud and waste, while also forcing efficiencies to make the process faster. For example, tighter control of the time spent between the defining of a requirement and the actual production of a commodity would significantly reduce the total acquisition time. The first phase of an acquisition is often defined as Administrative Lead Time (ALT), and the production phase assigned to a contractor is defined as Production Lead Time (PLT). Traditionally, ALT has consumed large portions of the program time due to multiple decision briefings, delays, and re-briefing. As PLT becomes compressed, it has become normal to experience major delays in obtaining the item. Should Army leadership refocus on the acquisition process, with the intent of streamlining, avoiding duplication, eliminating unnecessary delays, and reducing the multiple layers of supervision, then the Army's acquisition program will be better positioned to execute at the pace of expeditionary maneuver, while achieving better management of scarce resources.

As outlined, this initiative doesn't require any change to procurement law, or any additional cost to the Army. What is required is a change to the way the procurement process is designed and managed. By redefining priorities, rewarding qualified risk-taking, and streamlining management, the professionals who make up the procurement process will respond favorably, in turn creating better value for the Army, and providing more timely support to its warfighters.

3.4.3.3 ENERGY EFFICIENT PLATFORMS

There are numerous attributes of a Series Hybrid architecture (i.e., vehicles with two or more power sources in the drivetrain) which contribute to improved fuel efficiency:

- Decoupling the engine from ground enables engine operation at speeds that correspond to the optimum efficiency point for a given power level.
- Engines can be designed to operate at higher thermodynamic efficiency at a specific speed range since they do not have to produce high torque over a broad range.
- Energy storage systems allow recovery of braking kinetic energy and gravitational potential energy (from going down hills) for subsequent acceleration and hill climbing with less fuel.
- Supplemental power from an energy storage system allows reduction of installed engine power without compromising performance. On conventional drive trains, an engine sized for acceleration requirements uses excess power for most operational conditions. For a significant portion of the duty cycle, smaller engine(s) operate more efficiently at higher power levels than “oversized” engines operating at same power at part load. Smaller engines weigh less, have smaller cooling and ancillary support systems and reduce volume under armor. Smaller, lighter platforms inherently use less fuel to perform missions.
- Stationary power generation using only one engine to support checkpoint type mission roles greatly reduces fuel consumption rates.
- Dual engine architecture allows operation on a single engine during low power demands.

While these attributes benefit fuel economy when the vehicle is operated at speed over terrain, the architecture also provides great benefit during stationary vehicle operations, which is critical, since this represents a significant portion of the mission duty cycle. Architectural differences produce substantial, 180-day deployment fuel savings at the platoon level even when the mechanical alternative uses modern, 7-speed transmission and piston diesel engine characteristics (Figure 3.7).

Vehicle @ 25°C	*180-day Campaign Fuel Consumption (gallons)*	*Fuel Consumption Rate (gallons per hour)*	
		Basic Idle (no electrical power export)	*Tactical Idle (with electrical power export)*
70-Ton - Series Hybrid	8,931 (per Vehicle) 35,724 (4-Vehicle Platoon)	1.9	5.5 exporting 45 kW Future growth capability =1,000 kW
70-Ton - Mechanical Alternative	9,871 (per Vehicle) 39,484 (4-Vehicle Platoon)	2.8	7. 7 exporting 45 kW
Abrams M1 Main Battle Tank	14,700 (Vehicle) 58,808 (4-Vehicle Platoon)	10	3 to 5 exporting 6 kW

Figure 3.7 Fuel Consumption

3.4.3.4 WATER PRODUCTION, USE, AND REUSE

The Army has spent the past several years working with commercial industry to advance the ability to generate potable water from air, and to harvest gray water. Both efforts have matured the technology to at least technology readiness level (TRL) 6.[39] What remains to be accomplished is to architect the integration of the technology onto the correct platforms (water from air) and integrate the gray water recovery into the field support systems. In discussions with industry, the study team has learned this is achievable with minimal risk.

3.4.3.5 DATA MINING AND ANALYTICS

We now live in a world where information is power. Successful expeditionary forces in 2025 will exploit large databases for planning prior to conducting operations. However, commanders and staffs will face an ocean of data from a world becoming more open and descriptive of everything humans do and intend to do. From social media such as Twitter, to geospatial data from Google Earth (which will have sub-meter 3D data of the entire earth in 2025), to compiled databases of every piece of infrastructure (bottling plants, electric generation facilities, etc.), military leaders will have access to an abundance of data that didn't exist 15 years ago.

Much of the data is now generated in real time from mobile devices such as smartphones. Annual global Internet protocol traffic will pass the zettabyte (1000 exabytes; 10^{21} bytes) threshold by the end of 2016, and will reach 1.6 zettabytes per year by 2018. In 2016, global IP traffic will reach 1.1 zettabytes per year or 91.3 exabytes (one billion gigabytes) per month, and by 2018, global IP traffic will reach 1.6 zettabytes per year or 131.9 exabytes per month.[40]

These figures are hard to fathom, but within these data reside the keys to optimally tailoring an expeditionary force. For example, knowing where the bottling plants are may provide an alternative to transporting water. Biometric databases may enable identification of adversary leaders and locations. Knowledge of the target country's power grid may reduce requirements for generators. Looking for patterns in the data, or looking to assemble the data in meaningful ways, requires efficient algorithms, adequate data storage capability, and most importantly, a way to translate what a human is asking for into code or descriptions which then can lead to the right answer. This last step is usually the most challenging because sometimes, humans aren't aware of exactly what they want, so optimally, the algorithms need some heuristic feature which helps them learn from what humans have wanted in the past, and apply that to what humans may want now or in the future.

The study team proposes that expeditionary commanders use this data to generate *a priori* target folders, and that Regionally Aligned Brigades mine this information to build their contingency plans. To put in another way, commanders need to understand what data mining and analytics

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[39] Model or prototype system tests in a relevant environment (a major step up in a technology's demonstrated readiness), e.g., testing in a high-fidelity laboratory environment or a simulated operational environment.

[40] See "The Zettabyte Era—Trends and Analysis," part of the Cisco Visual Networking Index (VNI), available at: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.html

can do for them, and what they in turn need to do to realize maximum benefit from that capability. Both capabilities require analytical tools to explore the information and provide predictive analyses, and they need to be monitored in real time to identify major changes and anomalies that could impact operations.

3.4.3.6 EXPLOIT COMMERCIAL ASSETS – TRANSPORTATION

Distributed, mobile, small warehouses, continuously in motion, would require managing the float of containers within a CCMD’s AO across US Flag and non-US Flag operators. AMC has all of the command relationships to accomplish this concept by working with the vessel operators and LogCAP providers to determine whether containers were staged in specific, geographically central ports or kept afloat. Organizationally, AMC and its subordinate commands such as SDDC and Army Sustainment Command (ASC), in combination with the Engineer Support Battalion (ESB), would execute the concept. Techniques developed by companies such as Amazon that manage highly dispersed, distribution networks should be evaluated for managing the process.

3.4.3.7 EXPLOIT COMMERCIAL ASSETS – COMMUNICATION

The study team identified two enablers to help exploit commercial communications networks.

The first involves utilizing more commercial bandwidth and devices. Given the amount of R&D dollars invested by industry to develop technology that will be used on a global scale in support of global standards such as ISO, it’s clear that industry leaders expect there will be no place left in the world where the Internet is not present. Right now, every country in the world is connected to the global fiber network. By 2019, 4 billion people will be connected to the Internet via 4G cellphone technology, with 5G becoming dominant by 2025. 5G, which Samsung and Google are heavily investing in, will deliver gigabit communications. As the ubiquity of the Internet grows, so too will the trend toward an IOT, where every manufactured item, from cars to watches, will have some number of embedded processors connected into the Internet via wireless technologies such as Bluetooth or WIFI.

The Army cannot ignore these trends, as they will affect military equipment, from batteries to command systems. Adopting proprietary solutions for the Army would have made sense in the 1980s, when computing was generally limited to large businesses. It does not makes sense now. An expeditionary force should be prepared to use a host country’s telecom infrastructure. The Army does not have 10 years to build its own system, so protecting the existing, host-nation system will be critical. The Army will also need a strategy to securely use this global infrastructure, and to provide bridging to unique and propriety technologies. The study team expects future encroachment on the spectrum from commercial sources, which will limit the Army’s operational flexibility, unless it accommodates those commercial bands or uses non-regulated communications, such as high-bandwidth lasers.

The second enabler involves the use of optical communications. Optical communications spans both free-space and fiber-based communications links. A wide range of wavelengths are currently in use. Applications span near field communications (as an alternative to wireless) to ultra-long-haul submarine links, to interplanetary links. Nevertheless, most applications continue to experience a relentless need for increased capacity and increased electrical and spectral efficiency. The increasing use of cloud services for storage and processing is driving the need for increased capacity. Thus, optical communications has recently experienced increased leverage on a few common technologies, including high-speed integrated electronics, photonic integration, and signal processing. The increasing use of signal processing is enabled by high-speed electronics, and short-reach optical communications are becoming increasingly prevalent, in part due to the explosion of large data centers.

4.0 ASSESSMENTS

To evaluate the potential impact of the four advanced concepts, the study team undertook a preliminary assessment using the measures of effectiveness described in Section 1.2. The assessment focuses on deployment of a full SBCT, plus 30 days sustainment.

4.1 BASELINE

Sustainment requirements are estimated using the Quick Logistics Estimation Tool provided by CASCOM. Assuming deployment to an arid climate, Phase I-III Operations, and max intensity conflict, the SBCT requires 394.5 stons per day, or 11,835 stons for 30 days sustainment. This should be compared with 14,812 stons for SBCT equipment (Figure 4.1). Also note that 56% of the sustainment package is water and 25% is fuel. Ammo corresponds to 6%.

				Tonnage Required	
Class	Description	Gallons/Day	Lbs/gal	Daily	30 days
Class I	Food & comfort			18.9	567.0
Class II	individual equipment, tents, tools, housekeeping			3.6	108.0
Class III B	POL - bulk	28,070	7.00	98.2	2,947.4
Class III P	POL - packaged			0.3	10.2
Class IV BF	Construction equip – barrier/fortification			5.0	150.0
Class IV Const	Construction equip - other			7.1	212.7
Class V	Ammo			23.4	701.7
Class VI	Personal items (soap, toothpaste, snacks)			0.7	21.9
Class VII	Major end items (launchers, tanks, vehicles)			4.3	129.9
Class VIII	Medical			0.4	12.3
Class IX	Repair parts			0.5	13.8
	Soldier water	28,459	8.34	118.7	3,560.2
	Water, other potable	24,108	8.34	100.5	3,015.9
	Water, non-potable	0	8.34	0.0	0.0
	Ice			12.8	384.0
			TOTAL	394.5	11,835.0

Figure 4.1 Estimated SBCT Sustainment Requirements

A further breakdown of the units that comprise the SBCT was made based on data in the Deployment Planning Guide, SDDCTEA Pamphlet 700-5, 2012 (Figure 4.2). In the figure below, the third column (Strength) lists the number of personnel in the unit. The fourth column (# each) lists the number of those units in the SBCT.

				Tonnage (stons)/unit		
SRC	Title	Strength	# each	Equipment	30 day sus	% total
01708RB00	Tactical UAS (TUAS) Platoon	27	1	85	78	0.6%
05063R300	Engr Co, BDE (SBCT)	142	1	913	528	5.4%
06326R000	HHB, Fires Bn, 155T (SBCT)	92	1	201	228	1.6%
06327R000	Firing Battery, Fires Bn (SBCT)	90	3	254	407	2.5%
06530RA00	Tgt Acq HQ Team, Fires Bn (SBCT)	2	1	4	5	0.0%
06530RB00	WLRS (TPQ-36) Section, Fires Bn (SBCT)	4	1	25	14	0.1%
06530RC00	WLRS (TPQ-37) Section, Fires Bn (SBCT)	10	1	44	36	0.3%
06530RD00	Meteorological Team, Fires Bn (SBCT)	2	1	10	5	0.1%
06530RE00	Survey Tm, Fires Bn (SBCT)	2	2	0	5	0.0%
06530RF00	Counterfire Operations Section, Fires Bn (SB	6	1	4	13	0.1%
06530RG00	LCMR (AN/TPQ-48) Section, Fires Bn (SBCT)	10	1	15	29	0.2%
07093R300	Antiarmor Company (SBCT)	53	1	261	141	1.5%
07096R500	HHC Inf Bn (SBCT)	208	3	585	497	4.1%
07097R300	Rifle Co Inf Bn (SBCT)	163	9	434	386	3.1%
08108R000	Medical Co, BCT (SBCT)	75	1	179	213	1.5%
11103R300	Brigade Signal Co (SBCT)	56	1	116	182	1.1%
17096R500	HHT, Recon Squad (SBCT)	138	1	426	433	3.2%
17097R500	Recce Troop, Recon Squadron (SBCT)	92	3	364	276	2.4%
34117RA00	Surveillance Troop-SBCT	34	1	104	89	0.7%
34143R300	Military Intell Co, (SBCT)	77	1	99	190	1.1%
43107R000	Field Maintenance Co, Brigade Support Bn	352	1	1,741	941	10.0%
47102R500	HQ & HQ Company, STRYK	230	1	485	603	4.1%
63106R000	HHC, Brigade Support Bn (SBCT)	165	1	491	448	3.5%
63108R000	Distribution Co, BSB (SBCT)	158	1	2,098	687	10.4%
	TOTAL			14,812	11,889	100.0%

Figure 4.2 SBCT Sub-Units

The tonnage shown in the next columns corresponds to that needed to deploy each unit and must be multiplied by the number in column 4 to obtain the tonnage for the SBCT. The last column shows the percentage of the equipment and 30-day sustainment total associated with each unit. Note that Field Maintenance Company and the Distribution Company each account for approximately 10% of the total weight.

The time to employ is estimated based on data in the TRANSCOM SDDCTEA deployability study summarized in Appendix E. The average C-17 payload for each deployment situation addressed is 50 stons. For the baseline case described above, 296 C-17 sorties are required to carry equipment, and 237 sorties are required for 30-days sustainment, for a total of 533 sorties.

4.2 EXAMPLE CALCULATIONS

The time to deploy and number of C-17 sorties required scale with the product of tonnage and distance. Based on the data above, Soldier water corresponds to 13.4% of the SBCT tonnage. If that water can be obtained from local bottling plants at 20% of the distance (1,400 nmi rather than 7,000 nmi), then the number of sorties (and total time to deploy) is reduced by (13.4% x 80%) = 10.7%. Similarly, if other potable water (11.3% of tonnage) can also be found locally, then an additional reduction of 9.1% in sorties or time is possible.

The algorithms in the Quick Logistics Estimation Tool indicate that 30% of the SBCT tonnage (equipment plus 30-day sustainment) is directly proportional to the number of personnel. This corresponds to 1.9 stons per person for 30 days sustainment. Thus, any concept that reduces the number of personnel will also reduce the sustainment significantly.

4.3 COMPARISON OF CONCEPTS

RAND provided the study team with a framework for evaluating the four advanced concepts, based on tools and techniques associated with the Quality Function Deployment (QFD) methodology.[41] The evaluation compared the four advanced concepts against the status quo, and assessed their performance based on a set of scenarios.

The assessment process consisted of three steps:

1) Scoring each concept based on how well it performs with respect to each MOE
2) Weighting the MOE for each scenario, and
3) Aggregating the scores to assess the relative benefit and risk of each concept for each scenario.

4.3.1 STEP 1: SCORING CONCEPTS WITH RESPECT TO MOE

The concepts were evaluated as to whether the capability was better or worse with respect to the status quo for each MOE. For this analysis, the status quo was taken to be the projected capability provided by Force 2025 (Figure 4.3) Note that no concept was deemed to make the capability significantly worse than the status quo. Each concept received at least one +++ rating (significantly better than status quo) for the MOE corresponding to the strength(s) of the concept.

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[41] QFD is technique that identifies and translates customer requirements into technical specifications for product planning, design, process, and production. The methodology includes a structured procedure that starts with the qualities desired, leads through the functions required to provide those products and/or services, and identifies the means for deploying available resources to optimize the products and/or services.

For Dynamic, Capability-Based, Deployment Planning, that significant improvement was assessed in the time to employ MOE. The concept somewhat improved mission effectiveness by optimizing the forces deployed to match the mission. Technical maturity and cost were both assessed to be somewhat worse than the status quo, because some development is required in databases and software, but work has begun in that effort, so developmental is minimal. The concept moderately improved mission flexibility by enabling mission tailoring of the deployed force. It also provided some improvement in sustainment by reducing the size of the deployed force where appropriate, thereby reducing the sustainment burden. For the remaining three MOE, the capability was judged to be comparable to the status quo.

MOE / Concept	1) Dynamic Capability-Based Deployment Planning	2) Synchronized Distributed Interdependent Maneuver	3) Counter-Digitization	4) Adaptive Logistics
1. Time to Employ	+++	++	0	++
2. Mission Effectiveness	+	++	+++	+
3. Technical Maturity of Concept	-	--	--	-
4. Cost	-	--	--	-
5. Mission Flexibility Across Full Spectrum of Conflict	++	++	+++	++
6. Capability Against A2/AD Threats and Other Counters	0	+++	++	+
7. US Army Dependency on Outside Funding/ Operations	0	0	0	--
8. Ethical, Legal, and Social Acceptability	0	0	--	-
9. Sustainment of the Force (Maintainability, Medical, etc.)	+	-	0	+++

Key:

+++	Capability significantly better than status quo	0	Capability similar to status quo
++	Capability moderately better than status quo	-	Capability somewhat worse than status quo
+	Capability somewhat better than status quo	--	Capability moderately worse than status quo

Figure 4.3 Assessment of Concepts vs. MOE

The Synchronized, Distributed, Interdependent Maneuver concept was developed to address the A2/AD environment, and thus significantly improved the related capability with respect to the status quo. For some scenarios, small units provide initial entry forces, moderately improving time to employ a lethal force. In addition, manned/unmanned teaming (semi-autonomous lethal UGVs) can reduce the tonnage to be deployed for armored units, thereby improving time to employ. Mission effectiveness was moderately improved by use of unpredictable entry, distributed operations, advanced munitions, and semi-autonomous lethal UGVs. Many enablers for this concept require technical development, which led to an assessment that technical maturity and cost were moderately worse than the status quo. This concept improved mission flexibility through distributed operations and assured communications. Sustainment of the force was somewhat more difficult because the force is distributed. For the remaining two MOE, the capability was judged to be comparable to the status quo.

The Counter-Digitization concept significantly improved mission effectiveness, especially in the increasingly digital environment anticipated in the future. Defensive and offensive capabilities extend significantly improved mission effectiveness in all phases of conflict. Like the second concept, this concept relies heavily upon advanced technologies, which require development and increased cost. Defensive counter-digitization options help to mitigate the effectiveness of A2/AD, improving blue effectiveness in those environments. Some counter-digitization technologies may interfere with civilian electronics, and thus may raise issues of acceptability. For the remaining three MOE, this capability was judged to be comparable to the status quo.

Finally, the Adaptive Logistics concept was developed to address sustainment issues and was judged to significantly improve the capability beyond the status quo. Exploiting commercial transportation and local suppliers can moderately improve time to employ. Mission effectiveness was somewhat improved by reducing the logistics burden. This concept does not rely on advanced technology and was therefore assessed to be somewhat worse than the status quo with respect to technical maturity and cost. Mission flexibility was moderately improved by reduced logistics burden. Capability in an A2/AD environment was somewhat improved by reduced logistics burden. This concept is dependent upon commercial interests and thus was judged to be moderately worse than the status quo with respect to dependency on outside operations. Use of local infrastructure may impact civilian access to those services, and thus was judged somewhat worse than the status quo with respect to acceptability.

4.3.2 STEP 2: WEIGHING THE MOE

Integration of the assessments across the MOE would provide a unified comparison of the four advanced concepts. However, the nine MOE are not equally important, and their relative importance is scenario dependent. Thus, their performance may be different. Five scenarios were selected to explore the importance of the concepts in various types of conflict:

1. Show of Force in the Baltics – Baltic countries are threatened by Russia with both military forces on the border and irregular forces inserted (events proceeding rapidly so speed is essential, A2/AD a factor).
2. Beating Back the Islamic State of Iraq and the Levant (also known as Islamic State of Iraq and Syria) – ISIL is attempting to overrun an ally in the Middle East (speed is critical)
3. War in Korea – The "classic" war plan.
4. Defense of Taiwan – Invasion (forced reunification) of Taiwan by China (A2/AD a factor)
5. African Stabilization Mission – Land-locked African country requires immediate assistance in the face of regional insurgency.

These five scenarios help capture the uncertainty in the performance of each concept. The study team determined the relative importance of each of the nine MOEs for each of the five scenarios (Figure 4.4). These evaluations provided weighting factors for the MOEs for each scenario. Note that Time to Employ, Mission Effectiveness, and Technical Maturity are considered to be of the most relative importance in all five scenarios.

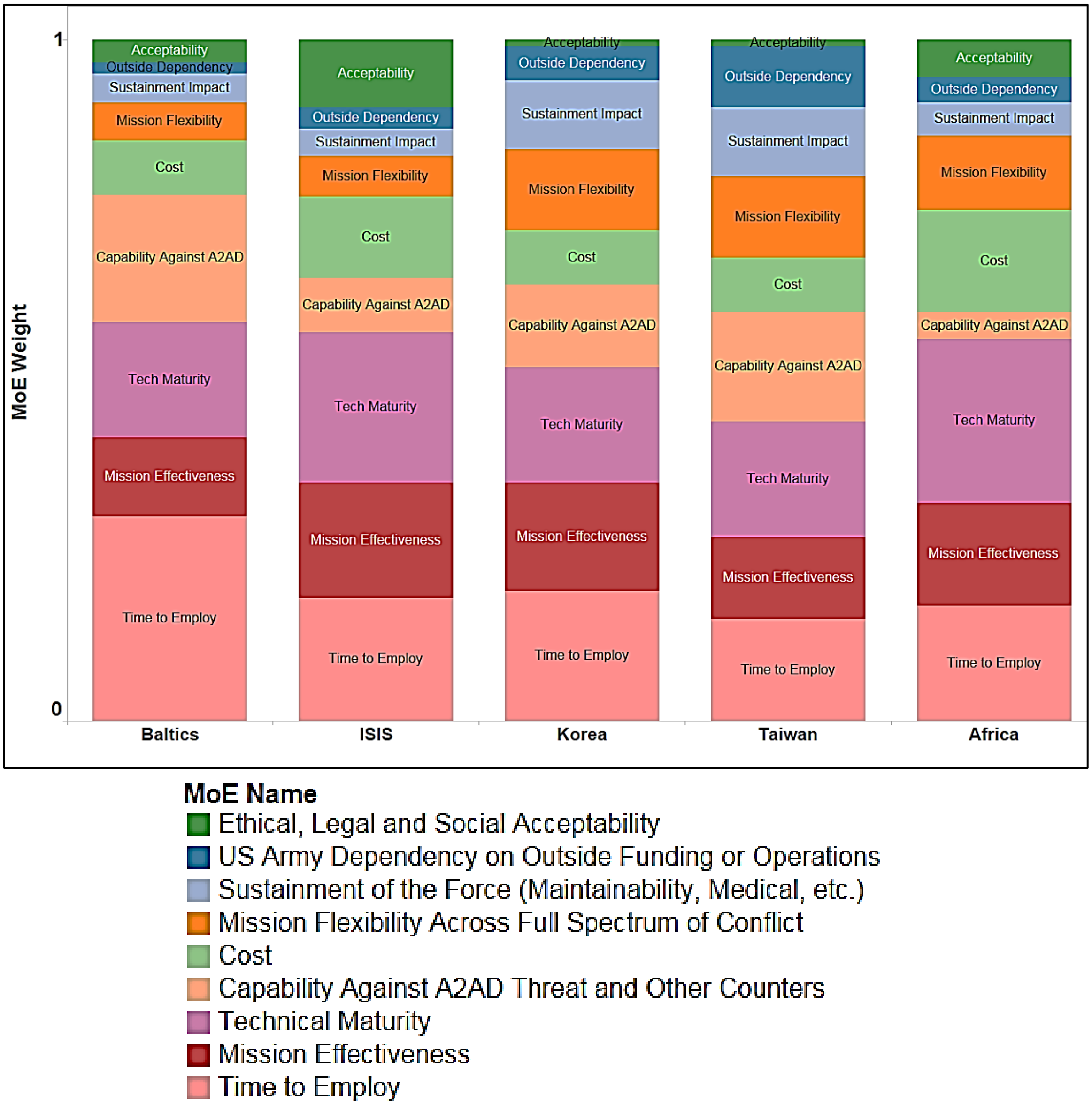

Figure 4.4 MOE Weights for Five Scenarios

4.3.3 AGGREGATING THE SCORES

In order to assess the risks vs. benefits for each concept, the MOE were divided into those addressing risks and those addressing benefits:

Benefit MOE	Risk MOE
1. Time to Employ 2. Mission Effectiveness 3. Mission Flexibility across Full Spectrum of Conflict 4. Capability Against A2AD Threat and Other Counters 5. Sustainment of the Force	1. Technical Feasibility and Maturity of Concept Solution 2. Cost 3. Army Dependency on Outside Funding or Other Operations 4. Ethical, Legal, and Social Acceptability

Figure 4.5 Benefit and Risk MOE

For each concept, the qualitative assessments obtained in Step 1 were converted to numerical scores on the 9-3-1 scale traditionally used for QFD. Then, for each scenario, the assessment scores for benefit MOE were added after multiplying them by the MOE weighting factor for the given scenario, to obtain a benefit score for the concept for that scenario. Similarly the assessments for the risk MOE were combined to obtain a risk score. These scores were plotted (Figure 4.6), as were the average scores across all five scenarios for a given concept (the small, solid dots in Figure 4.6).

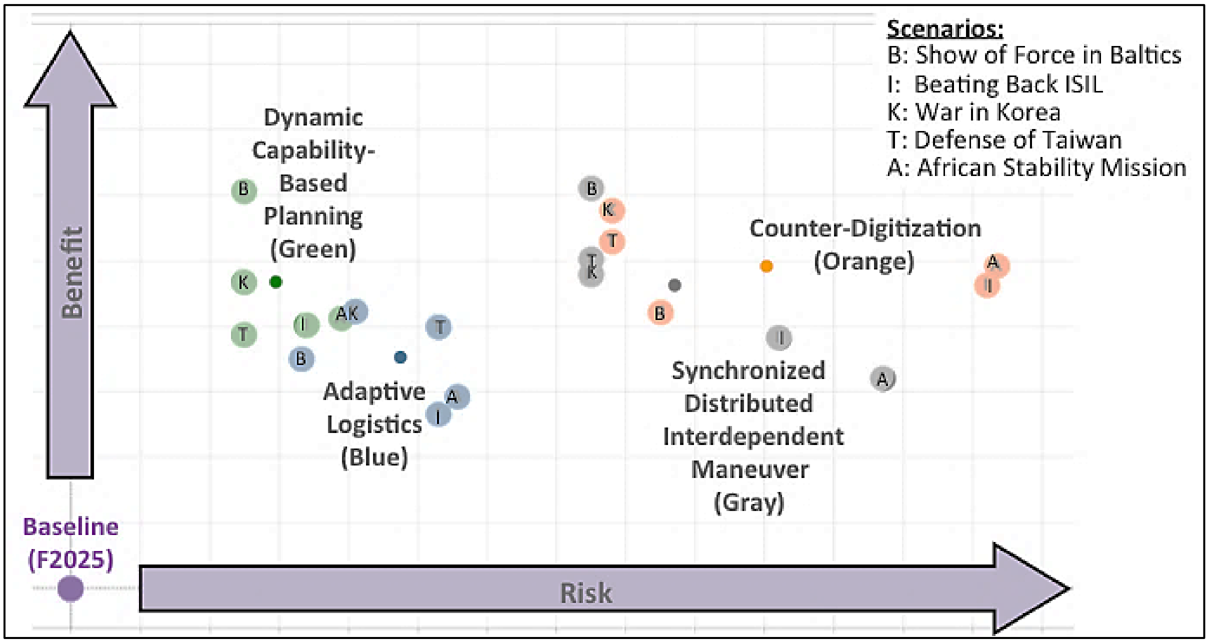

Figure 4.6 Risk vs. Benefit Scores for Five Scenarios

Once plotted, ellipses were overlaid by hand to highlight the results for all five scenarios for each concept indicated (Figure 4.7). They represent a measure of uncertainty with respect to the risk and benefit associated with each concept.

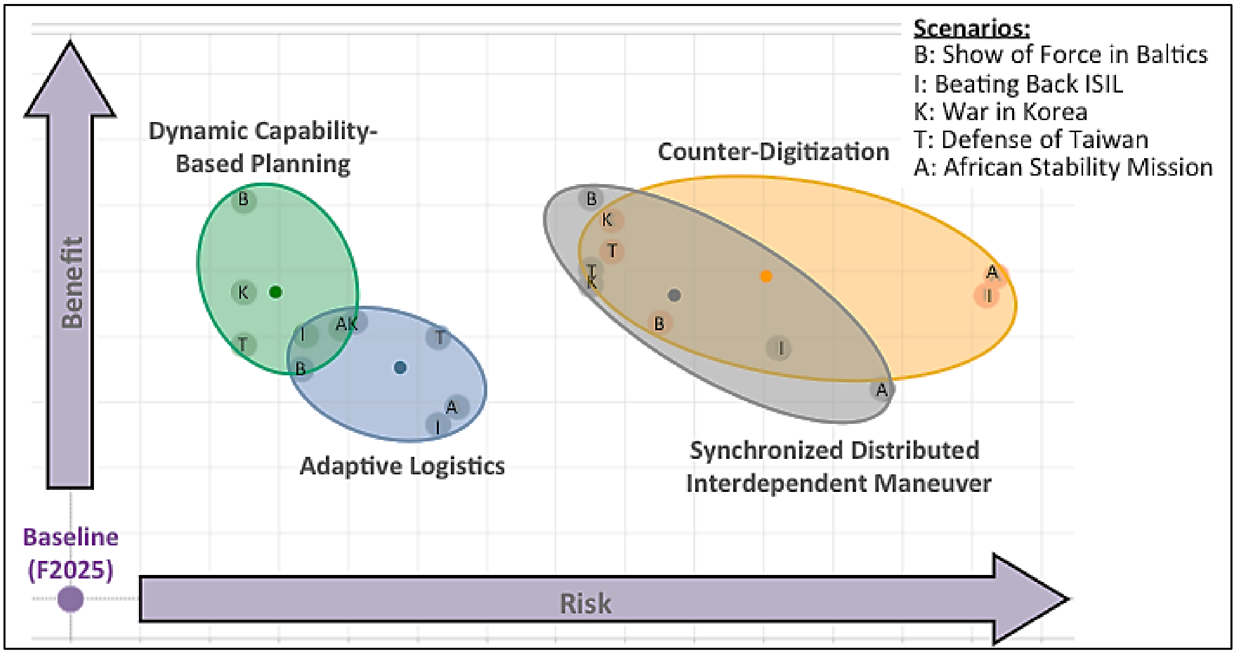

Figure 4.7 Risk vs. Benefit Ellipses

The results show that all four concepts provide benefits over the baseline, at different levels of additional risk. The organization-focused concepts (Dynamic, Capability-Based Planning and Adaptive Logistics) are achievable with less risk than the hardware-intensive concepts (Counter-Digitization and Synchronized, Distributed, Interdependent Maneuver). Counter-Digitization and Synchronized, Distributed, Interdependent Maneuver have comparable risk and benefit scores, as well as the highest sensitivities to scenarios. These are indicated by the greater spread of the scenario-based results, and the associated larger size of the ellipses.

5.0 LEVERAGING JOINT AND PARTNERING CAPABILITIES (TOR TASK 2)

The second task in the TOR directed the study team to examine options for leveraging Joint Force, commercial, and partnering opportunities, to improve strategic and expeditionary maneuver.

For the Army to deploy more efficiently, while also becoming a more effective force on the ground during the first 30 days, reliable Joint Force solutions should be sought. There are some things from the Joint force that could help reduce the Army's initial lift burden when they are available. For example, if the Army could rely on Navy hospital ships in the first 30 days of an engagement, there might be some Army medical personnel and/or medical units that could be removed from the initial deployment, and that space on a C-17 could be used for something else. Likewise, there are opportunities to leverage joint support for ISR, fire support, and close air support from the Navy and Air Force that, again, in the early phases of conflict, could be coordinated and could help the Army better optimize how it loads out air lift. The study team is not advocating that the Army rely upon Joint support in all situations, nor that it relinquish capabilities in the areas where it seeks support. Rather, the opportunities to leverage Joint support, outside of the roles defined in Title 10, should be pursued where it benefits strategic and expeditionary maneuver.

To better illustrate the benefits of using Joint Force solutions, the study team conducted an analysis calculating the sensitivities of deployment times for mission-tailored Stryker brigade units (see Sections 3.1 and 3.2.3.1 above). One of the options evaluated was a scenario where Joint fires support was available as Army forces entered the AO. In that scenario, the study team delayed elements of the brigade's fires battalion, based on the assumption that the Joint fires capabilities could replace the brigade's organic artillery capability. As a result, the other components of the brigade moved forward in the deployment process, and the recalculated deployment times suggest the brigade was mission capable 15% sooner than it would have been using the standard deployment process (Fig. 5.1). In the model, the 15% translated to 3-6 days, depending upon the number of aircraft used.

PHASE	DESCRIPTION	STANDARD DEPLOYMENT		JOINT FIRES SUPPORT	
		20 C-17	40 C-17	20 C-17	40 C-17
1	3 Company Teams	7.1	3.5	5.2	2.6
2	3 Battalion Task Forces	29	14.5	23.8	11.9
3	Brigade (w/o sustainment)	35.9	18	30.2	15.1
4	Brigade (w/ sustainment)	51.6	25.8	51.6	25.8
		Time (in days) to deploy			

Figure 5.1 SBCT Deployment Times with Joint Fires Comparison

Several additional variables will affect the actual deployment time of a tailored SBT that leverages Joint fires support, but the initial assessment conducted by the study team produced a significant enough change in calculated deployment timelines to warrant further inquiry by the Army.

Using Joint Force solutions to free up lift capacity and to optimize deployment timelines is extremely scenario-dependent, and it was beyond the scope of this study to conduct analyses on every possible scenario. The availability and applicability of Joint Forces support will vary by the specifics of any given scenario.

It was also beyond the team's scope to determine whether and how Joint Force solutions serve as viable alternatives for organic Army units. While there is precedence for substitution, Army planners and leadership will have to make those determinations, and gauge whether the substitutions are worth making to maximize lift and make space for other critical needs. For example, what constitutes sufficient Joint fires support that would eliminate the need to bring artillery early in the SBCT deployment process?

Where Joint Force solutions are restricted,[42] the Army could further examine the services it provides with an eye toward reducing its lift burden. The Army is assigned the following responsibilities (Figure 5.2), and performs them for the other Services.

ARMY TITLE 10 RESPONSIBILITIES	
• Airdrop Equipment and Supplies • Civil Affairs • Common User Land Transportation in Overseas Areas • Communications • Distribution • DoD Biometrics • **DoD EPW Program** • **DoD Executive Agent for Armed Services Blood Program Office (ASBPO)** • **DoD Executive Agent for DoD's Military Immunization Program** • **DoD Executive Agent for Mortuary Affairs Program** • **DoD Executive Agent for the Armed Forces Institute of Pathology (AFIP)** • **DoD Executive Agent for the DoD Customs Inspection Program** • **DoD Executive Agent for the Military Postal Services** • **DoD Executive Agent for Veterinary Services** • DoD Immunization Program for Biological Warfare Defense	• General Engineering • Health Services • Joint Tactics, Techniques, and Procedures for Joint Logistics Over-the-Shore (JLOTS) • Maintenance • Medical Biological and Chemical Defense Research • Noncombatant Evacuation Operations (NEO) • Overland Petroleum Support in Wartime • Patient Evacuation • **Program Land-Based Water Resources to Support the Geographic Combatant Command (GCC) Requirements** • Provide Supply • Provide Treatment for Enemy Prisoners of War (EPWs) and Civilians • Single Integrated Medical Logistics Management (SIMLM) • **Single Manager for Conventional Ammunition (SMCA)** • Transportation
NOTE: items in **bold** indicate services where the Army acts as executive agent	

Figure 5.2 Army Title 10 Responsibilities to Joint Force

Eliminating some of these responsibilities could possibly reduce the Army's deployment burden, but shifting responsibility may not produce efficiency in the overall requirement, as other Services may not support the requirements as efficiently as the Army. Here again, Army planners and leadership will have to determine whether and how Joint Force solutions are viable alternatives. It's not likely that the Joint Staff would simply eliminate

[42] In so far as Title 10 assigns various responsibilities across the Services to reduce overall burdens, and to reduce overly redundant capabilities.

these requirements, though the timing and phasing into the AO may be negotiable, thereby opening load space during the first 30 days.

With regard to commercial opportunities, there are significant areas to lighten the Army's load by leveraging commercial techniques and applications, most promisingly in the areas of communication and cargo transport (see section 3.4 above). Commercial opportunities are also available to mitigate the challenge of moving water to the AO, which is the largest burden on lift in the first 30 days of deployment. For a SBCT, Soldier-consumed water constitutes about half of the 30-day sustainment load, and about 25% of the entire lift burden for the Brigade (see Sections 2.1 and 4.2). Thus, making use of commercial opportunities in, or closer to the AO (see Section 3.4), would provide significant relief in lift capacity, freeing up space to adjust phasing of the deployment to better optimize the force. For example, if the Brigade eliminates the need to transport water by acquiring it from a local source on day 10 in the AO, other components of the brigade can be moved forward in the deployment process, and the study team posits the Brigade would reach 70% lethality[43] about 11 days sooner than a standard SBCT deployment (Fig. 5.8).

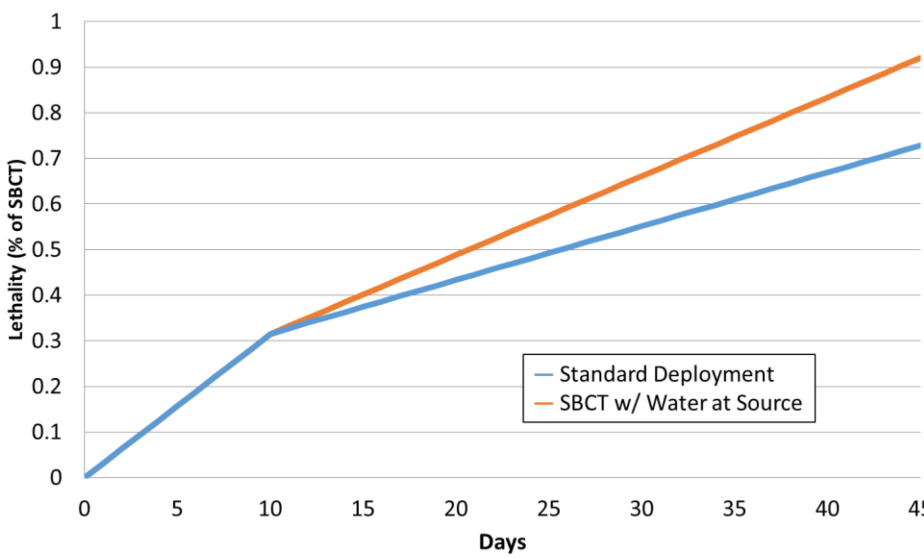

Figure 5.3 SBCT Deployment Times with Water Comparison

Finally, partnerships with coalition nations provide opportunities for prepositioning, stationing, and sustainment, which would enhance strategic and expeditionary maneuver by reducing requirements and the associated burden on lift. The development and maintenance of these partnerships could be facilitated by the emergence of Regionally Aligned Forces (RAF):

> RAF is a critical first step in operationalizing the concept of "Strategic Landpower," which is the combination of land, human, and cyber activities that make decisive outcomes more likely, and increases options for preventing and containing conflict. RAF is integral to the

[43] Defined by the number of combat vehicles in the AO.

> Army vision of being "Globally Responsive and Regionally Engaged" and it is fundamental to our ability to "Prevent, Shape and Win" across the globe. It is essential to the US defense strategy and represents the Army's commitment to provide culturally attuned, scalable, mission-prepared capabilities in a changing strategic environment characterized by combinations of nontraditional and traditional threats."[44]

The Army's fiscal year 2013 Strategic Planning Guidance states the future force will provide mission-tailored RAF, scalable in size from squad to corps. Its personnel are to be empowered by technology and training to execute operations under the concept of mission command, underpinned by trust, flexibility, and proficiency. The operating force will thus comprise forces both regionally aligned in support of combatant command and those maintaining a global orientation for specific contingency missions.[45] Within the relationships that the RAF will build, the logistics component of Strategic Landpower needs to receive priority attention, so as to leverage advantages for expeditionary operations.

[44] US Landpower in Regional Focus - Regionally Aligned Forces: Business Not as Usual, Kimberly Field, James Learmont, and Jason Charland in Parameters 43(3) Autumn 2013.
[45] Headquarters, Department of the Army, *Army Strategic Planning Guidance,* 2013, 6.

6.0 RELEVANT TECHNOLOGIES FOR 2025 AND BEYOND (TOR TASK 3)

The study TOR tasked the study team to identify Army, other DoD, other USG, industry, university, and FFRDC research, technology, engineering and innovations for 2025 and beyond. To achieve this, the study team went through a modified Delphi process whereby each study team member was asked to identify those technologies that he or she viewed as supporting strategic and expeditionary maneuver, and which would be sufficiently mature by 2025 or thereafter to warrant deeper consideration for Army use. The material used by each member varied, from his or her own professional knowledge, to information gleaned from visits and interviews conducted during the study. A list of over 30 technologies was constructed from this input. The study team then debated and refined this list, which included removing some technologies because they would be reasonably available prior to 2025, and those technologies are addressed in other sections of this report. From this review process, the study team identified 10 technology areas considered to offer the best potential for 2025 and beyond. Each area supports at least one of the key concepts, and is described in greater detail below:

TECHNOLOGY AREAS	ADVANCED CONCEPTS			
	Dynamic Capability-Based Deployment Planning	Synchronized Distributed Interdependent Maneuver	Counter-Digitization	Adaptive Logistics Support
1. Automated offensive and defensive cyber	✓	✓	✓	✓
2. Stealthy, swarming, micro, cross-domain UAVs; automated platforms		✓		
3. Sense-making data fusion, wide-area ATR		✓		
4. Fusion of LIDAR and electro-optical sensors, green-sensitive camera, air-cooled laser		✓		
5. Advanced weapons		✓		
6. Anti-missile and advanced directed energy		✓	✓	
7. Deployable water treatment and purification				✓
8. Advanced materials and manufacturing				✓
9. Fuel cell, batteries, and solar photovoltaics				✓
10. Thermoelectric waste heat generation				✓

Figure 6.1 Ten Promising Technologies for 2025 and Beyond

Note that the ten technology areas aren't ranked in any particular order. Furthermore, the level of detail in the descriptions below should not be read as reflecting the level of import the study team places on any particular technology.

6.1 AUTOMATED OFFENSIVE AND DEFENSIVE CYBER

This technology area represents what the study team believes to be the natural evolution of cyber technology, namely, a migration from mostly human-mediated interactions to some computer-driven actions and reactions for both offensive and defensive measures. An even longer term goal is to have computers take offensive and defensive measures with little if any human intervention, but realizing this goal has many challenges in the technical, ethical, and legal areas; several of the technical challenges are discussed below, but to emphasize, they are only part of what must be overcome to realize true autonomy of action.

Today, most cyber defensive measures used to protect networks and end-points employ access control mechanisms (at the network and at the host layers) requiring user authentication, and intrusion detection systems (also at the network and at the host layers) to detect anomalies and alert human overseers to take appropriate action. By contrast, intrusion prevention systems detect and react automatically, subject to human-defined rulesets, when anomalies are detected. Unfortunately, intrusion prevention systems are burdened by three limitations: (1) the rulesets can be very large and hence cumbersome to manage; (2) the rulesets are not very flexible (they typically do not change dynamically, and to avoid instability, any changes usually do warrant human review); and (3) the opportunities for false positives (anomaly is detected when in fact there is no anomaly) and false negatives (no anomaly is detected when in fact there is one) are high. Depending upon what action is taken in the event of a false positive, the network may shut down services or take other actions which reduce both its ability to be attacked further, and also its ability to deliver the services that the combatants require; hence automated action in response to an intrusion can create degraded conditions, making false positives very dangerous in any autonomous system.

While access control will always play an important role in protecting the network and resources on the network, one has to assume that such measures will fail, i.e., that the network and resources will ultimately be penetrated. This elevates the importance of intrusion detection and protection mechanisms. Going forward, the evolution of such systems is aimed at producing software that is heuristic (i.e., learns from its experience and self-improves), improving both false positive and false negative error rates, while at the same time providing much greater flexibility in creating and managing rule sets. Use of such software reduces the time delay of having humans review and react to intrusions. The faster response time provides better ability to isolate an intrusion and to minimize the likelihood that any malware implanted by the intrusion will proliferate quickly to the point where it debilitates friendly assets.

Careful integration of intrusion detection/prevention systems with access control mechanisms strengthens both. This is usually done through strong (two factor) authentication and “least privilege” (“need to know”) authorization management. While there are many such mechanisms available today, they focus on user accounts of humans rather than so-called “service” accounts assigned to devices, where authentication has been difficult to perform reliably. A device must be able to prove its identity using information within the device, which can be more readily compromised than a human brain (social engineering does work well with many humans, but is less effective against trained staff). Thus, in dealing with programmable logic controllers (PLCs) or supervisory control and data acquisition systems (SCADA), a new security paradigm will be needed for access control.

To illustrate these points, in large commercial enterprise networks today, there is little if any “automated” defensive response to intrusions, precisely for the reasons cited above. The potential for false positives in a deployed network is even higher given the nature of the network and the fact that network management teams lack historical data on “normal” network behavior (the deployed network may have just been set up).

Regarding cyber offensive abilities, replacing humans with automated systems is even more complex and further away from realization. This is because, unlike defensive measures, where actions are taken within one’s own network and host systems, offensive cyber operations reach into networks and assets not owned by the attacker. Thus they have substantial potential for creating collateral damage and revealing the methods and code used for the attack, which can then be turned around on the attacker. As a result, substantial additional R&D will be needed in this area before significant automation becomes tenable.

In sum, it must be emphasized that for the foreseeable future, there is no substitute for the well-trained, human professional making key decisions regarding cyber operations, both offensive and to a lesser degree, defensive. One should not view this technology area as evolving in the near future to the point where humans can be removed from the loop entirely. Rather, for defensive cyber operations in particular, the evolution is likely to result in software that can reliably react to a subset (that will grow over time) of detected intrusions, or initiate other actions, with human intervention reserved for more ambiguous or uncertain situations. This is the state of affairs the study team believes will emerge within the next 10 to 20 years.

6.2 STEALTHY, SWARMING, MICRO, CROSS-DOMAIN UAVS; AUTOMATED PLATFORMS

The study team believes that there is great potential to improve the situational awareness and lethality of combat units through the use of semi- and fully-autonomous unmanned air vehicles (UAVs) and unmanned ground vehicles (UGVs) that work collaboratively with other unmanned vehicles and with their human partners. The robotic vehicles in these manned-unmanned teams will vary in size from micro-scale to full-scale vehicles based on the requirements of the mission. At the micro-scale, the vehicles will primarily be used to survey the battlefield and gather intelligence, and in some cases, they will also swarm in a manner similar to insects. At the medium-scale, the vehicles will be used for surveillance and intelligence gathering, as well as the delivery of ordnance. At the full-scale, the vehicles will be used for the delivery of ordnance and for autonomous logistics. At all scales, the vehicles will either be controlled remotely by the human members of the team, or they will operate autonomously.

Placing robotics on the modern battlefield, more pointedly in the hands of our soldiers, will go a long way toward reducing the inherent risk of combat. In fact, the Army has already benefited from the use of UAVs and UGVs for surveillance and intelligence gathering from a safe standoff distance, and similarly from the use of UGVs to disarm unexploded ordnance. Besides keeping our military members out of harm's way, unmanned air and ground vehicles with non-lethal weapons will allow army units to gain control of a situation. They will also be used as a platform to fire various nonlethal projectiles such as rubber bullets, rubber balls, or bolas, and for the discharge of chemical agents such as pepper sprays and tear gas, all of which incapacitate or render the target harmless.

One major advantage to using unmanned vehicles as a platform for lethal weapons is that they can be maneuvered into highly dangerous areas and, if necessary, sacrificed to ensure precise delivery. The only technological limitations to the mounting of lethal weapons on UAVs and UGVs are the size and weight of the weapon, and the means of discharge. Thus, the ability to fire lethal armaments from UAVs and UGVs is not constrained by technology, but rather by policy and doctrine, especially with regards to vehicles that operate autonomously. One particular concern is the possibility of accidental firings resulting in friendly fire casualties, civilian losses, or collateral damage due to technical difficulties, loss of control, or misidentification of targets.

The key to unleashing the potential of UAVs and UGVs within the context of coordinated manned-unmanned teams is therefore the mastery of autonomy. As stated in the Defense Science Board report[46] on “The Role of Autonomy in DoD Systems,” autonomy has matured to the point where it is now being exploited for military operations. For example, the mission scope of UAVs has expanded in recent years from tactical reconnaissance to a wider array of missions, because UAVs can maintain sensors and precision weapons over an area of interest at great distances for longer periods of time. The integration of ISR and strike capability on the same unmanned platform, coupled with direct connectivity of UAV operators to ground forces, has led to reduced reaction time and is saving lives of U.S. troops on the ground. Further, autonomous technology is increasing the safety of unmanned aircraft during auto-takeoff and landing (for those organizations leveraging that technology) and reducing workload. UGVs provide similar value to UAVs on the battlefield, both in terms of persistence and standoff capability.

In the 2025 time frame, the study team expects autonomy to be an integral part of Army operations at all levels. At the infantry unit level, the study team envisions UAVs and UGVs that serve as independent scouts operating at, and beyond, the traditional range of human scouts. These machines would be able to autonomously identify and acquire hostile targets, thereby increasing both the situational awareness of the unit and its lethality. Unmanned scouts will leverage the object recognition and decision-making technology that is now being fielded and improved within the context of autonomous vehicles (e.g., the Google self-driving cars). Additionally, such UAV and UGV scouts will have multi-frequency sensor arrays that will enable them to detect such threats as improvised explosive devices (IEDs). The study team also expects there to be autonomous mules (Figure 6.1) for the transport of goods and supplies, thereby reducing the need for soldiers to carry supplies on their person, and freeing up carrying capacity for devices that improve connectivity, decision-making, and lethality. We also expect UAVs to be an integral part of a layered and resilient communication network that provides improved situational awareness and coordination on the battlefield.

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[46] The Role of Autonomy in DoD Systems, Defense Science Board, July 2012, DTIC ADA566864.

Figure 6.2 Semi-Autonomous Mule Operating in a Manned-Unmanned Unit

The study team also expects autonomy to provide significant benefits at the platform level by enabling joint mounted/unmounted vehicle teams, where autonomous vehicles that can deliver precision fires move and work in coordination with vehicles controlled by humans. The distribution of autonomy and human intelligence, as well as automation and human action, will be optimized based on the requirements of the mission and the capabilities of the underlying technology. For example, if it is possible to automate the entire process of loading and delivering precision ordnance, as we expect it will be, the autonomous vehicle will have no human occupants. Such a concept is well described by the TARDEC concept for a Main Battle System (MBS) platoon (Figure 6.2).

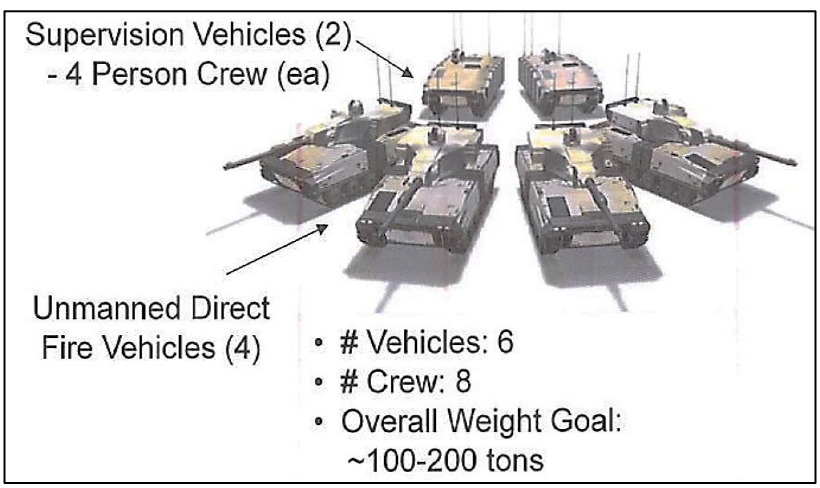

Figure 6.3 TARDEC Main Battle System (MBS) Platoon Concept

Synchronized operations involving rapid deployment and target detection, acquisition, and destruction may be coordinated via UAV-enabled, local-area network (Figure 6.3). Such operations will make it possible to airdrop precision fires that could autonomously configure themselves for combat and then work semi-autonomously with a supervisory agent (as a unit would within the traditional command and control structure). Given that the autonomous, unmanned components of this manned-unmanned team could be deployed in areas where the risk to manned components is too high, such a team would greatly enhance lethality.

Figure 6.4 Synchronized Target Detection, Acquisition and Destruction

Another area where autonomy is expected to have a significant impact on capabilities in 2025 is logistical movements (Figure 6.4).Currently, land convoys bear significant risk during their movements. The risk to humans could be greatly reduced if all the various supply lines were to be operated autonomously and without the need for human presence in vehicles. Further, the speed of, and some of the risks associated with, initial deployment in hostile territory could be reduced through the use of autonomous aircraft loaders.

Figure 6.5 Autonomous Unmanned Convoy

6.3 SENSE-MAKING DATA FUSION, WIDE-AREA ATR

Over the past 13 years the Intelligence Community (IC) has introduced a large number of strategic and tactical systems to provide a wide range of sensor data to Army operational commanders. A major challenge in operationalizing these data has been "connecting the dots" among disparate sources. Task Force ODIN in Iraq demonstrated the importance of fusing data from a wide arrange of sources in real-time to attack asymmetric adversaries and destroy their IED/bomb-making networks.

A recent approach to sense making, known as Activity Based Intelligence (ABI), shows significant progress. ABI is emerging as a powerful tool for understanding adversary networks and solving challenges presented by dense megacities and big data. For example:

> NGA Director Letitia Long has said the agency is using ABI to “identify patterns, trends, networks and relationships hidden within large data collections from multiple sources: full-motion video, multispectral imagery, infrared, radar, foundation data, as well as SIGINT, HUMINT and MASINT information. The technique appears to have emerged when special operators in Iraq and Afghanistan reached back to NGA analysts for help plugging gaps in tactical intelligence with information from national-level agencies. These analysts began compiling information from other intelligence disciplines — everything from signals intelligence and human intelligence to open sources and political reporting — and geotagging it all. The resulting database could be queried with new information and used to connect locations and establish a network.”[47]

ABI is made possible by the ability of sensors to share and place large amounts of data in virtualized cloud computing environments supported by High Performance Computing (HPC). However, HPC performance has been slowing due to the diminishing returns of Moore’s law as traditional silicon based CPUs meet their ultimate physical compute per watt limits. IARPA has taken the lead in the IC in researching new computing architectures such as quantum and cryogenic computing.

Another, more pernicious “bottleneck,” is the lack of trained commanders and operators who can exploit this data. This is partly because of Title 10/50 barriers to use IC sensors and automatic target recognition (ATR) in CONUS. Additionally, most non-MI Army tactical commanders lack the clearances to use the data directly in CONUS. There is a real danger to an expeditionary Army that units will not take (or request) the necessary ATR systems on deployment, either out of ignorance, or simply because they have never exercised and trained with the systems in CONUS. Re-establishing a Task Force ODIN, in a timely manner, will be a major challenge, unless the Army can overcome the restrictions of Title 50.

6.4 FUSION OF LIDAR & ELECTRO-OPTICAL SENSORS, GREEN-SENSITIVE CAMERA, AIR-COOLED LASER

Airborne LIDAR technology, has become an important component of the national ISR enterprise. Quick reaction capability (QRC) systems have been deployed to Afghanistan and Iraq and have been used for wide area mapping (WAM), creation of tactical decision aids (TDA), detection of IEDs, development of targeting portfolios, and conducting damage assessments. Generally, these

[47] See Gabriel Miller’s article, “Activity-Based Intelligence Uses Metadata to Map Adversary Networks,” in Defense News online version (8 Jul 2013) at: http://www.defensenews.com/article/20130708/C4ISR02/307010020/Activity-Based-Intelligence-Uses-Metadata-Map-Adversary-Networks

QRCs were developed and deployed in response to JUONS, and were highly successful in developing key technologies and facilities[48] required to get data into the hands of decision makers and war fighters. The first such system was Buckeye, developed and deployed by the Army Geospatial Center (AGC). Buckeye combined LIDAR and high-resolution images to produce 3D data products supporting mission planning and operational efforts. The success of the Buckeye program suggested evolutions to LIDAR technology, including deployment from higher altitudes, development of streamlined procedures for data processing, development of error propagation models for LIDAR systems, and the fusion of LIDAR data with other EO sensors to better support foliage penetration (FOPEN). During the same time period, the Army Corps of Engineers (USACE) jointly developed with the Naval Oceanographic Office (NAVOCEANO) the Coastal Zone Mapping and Imaging LIDAR (CZMIL). This system fused LIDAR and hyperspectral images (HSI) to produce high-resolution images of the shallow water seafloor and topographic images of the beach.

Continued development of data fusion architectures combining LIDAR with hyperspectral and thermal images offers promise for a number of challenging missions, including detection of targets under dense canopies and identification of specific targets and threats. In these endeavors, 3D shape, structure, and texture measured from LIDAR data are combined with color or thermal spectra to improve battle space awareness beyond what can be achieved with any single sensor. This combination of target characteristics can be analyzed with machine learning and cognition software to locate and identify specific targets. Current trends in related data fusion research are focused on accelerating data processing and reducing the complexity of the hardware and software.

The success of Buckeye and subsequent QRCs has raised interest in using LIDAR data for targeting applications. To do so, the LIDAR data and derived products must be available to mission planners quickly, and the 3D accuracies must be well understood. In the past year, the National Geospatial-Intelligence Agency (NGA) implemented a requirement that accuracies of all LIDAR data must be computed using techniques that propagate known errors on the measurements onto the coordinates. This process is called total propagated uncertainty (TPU). The development of TPU models for the QRC LIDARs is an area of active interest, as are techniques for computing these accuracy estimates in near-real time.

There is also interest in using CZMIL and other bathymetric LIDARs for ISR applications. Although CZMIL was developed primarily as a bathymetric mapping system, it is a superb technology for anti-mine and anti-submarine warfare. It also is an excellent FOPEN system. The primary concern with using bathymetric LIDARs for FOPEN applications is that the green laser is not covert. This concern has led to interest in deploying bathymetric LIDARs from higher altitudes for FOPEN applications, and from its usual lower heights for bathymetric applications – thus yielding a multi-mission capability for the LIDAR. Bathymetric LIDARs are typically higher-powered and larger than topographic LIDARs, and require significant data processing time to produce products. Consequently, the two most important areas of research and development in bathymetric LIDAR

[48] PCPAD (planning and direction, collection, processing and exploitation, analysis and production, and dissemination) facilities.

are related to development of miniature and real-time systems. These smaller, faster systems would enable deployment on unmanned aerial vehicles.

In addition to supporting ISR applications, LIDAR systems are being integrated into systems supporting pilotage in degraded visual environments (DVE). Ongoing development of DVE systems are generally following a data fusion paradigm, combining LIDAR, radar, and thermal images to provide a real-time synthetic vision capability. In such fusion systems, the LIDAR provides the highest fidelity and highest resolution data by acquiring dense 3D data before the DVE becomes severe (in the case of DVE arising from dust), and thereby generates data to be used in a see-and-remember scenario. Active areas of research in the DVE application of LIDAR are the development of real-time coordinate computation and data-fusion procedures, and the rapid sharing of these data with other aircraft on the same mission. This application is also critically dependent on the quality of navigation data. Therefore, there is strong interest in developing applications that work in a GPS-denied or degraded environment.

The momentum in all applications of LIDAR is toward smaller, UAV-deployable systems and flying higher. Higher altitudes solve two problems: (1) greater area coverage rate, and (2) greater safety for the aircraft when operating in contested areas. But increasing the altitude also requires pulsing the laser more frequently. Thus, there is a complex trade space between lasers and detectors as they affect spatial resolution of the data. One path for designing new systems has been to use array detectors such as the 32x32-element Geiger-mode avalanche photodiode, and to broaden the pulse footprint so as to operate the LIDAR in a flash camera mode. Specifically for bathymetric LIDAR applications, there is interest in using these array detectors to increase the resolution of seafloor 3D imaging. But the array detector options in the green are limited by the need for green-sensitive cameras.

6.5 ADVANCED WEAPONS

Advanced weapons, including precision fires/munitions and multi-purpose rounds with scalable-effects warheads, can provide significant force-multiplier effects and greatly enhanced overall mission effectiveness for expeditionary and follow-on forces. Their deployment and use also offers potential logistics benefits through realizable reductions in the ammunitions load, platforms, personnel, and mission-execution efficiency. Advanced weapon types include infantry support weapons, artillery, anti-tank guided missiles (ATGMs), long-range missiles, and mortars. Their utility and combat effectiveness has been demonstrated in numerous engagements by fielded systems such as Javelin, Excalibur, GMLRS, M795 155mm Precision Guidance Kit (PGK,) and Accelerated Precision Mortar Initiative (APMI). Current capabilities reflect major technological advances realized over many decades of development.

There are numerous ongoing precision munitions and other advanced weapons developments that have significant potential to enhance the capabilities of expeditionary forces by 2025 and beyond. The study team selected examples of important, ongoing work at ARDEC and AMRDEC. Note that, as with the larger technology areas, the following examples aren’t ranked in any particular order. Furthermore, the reader should not infer the descriptions below constitute additional findings, program reviews, or endorsements of particular weapons systems, nor do the reported TRLs reflect an independent ASB assessment of technical maturity.

1. The Individual Assault Munition (IAM) – IAM is the next-generation lightweight (≤ 15 lbs.), man-portable, disposable, shoulder-launched weapon designed to enable the Objective Force Warrior to dominate close-range engagements in complex and urban terrain. A multi-purpose weapon, it will combine all of the best features of the M72 Light Anti-tank Weapon (LAW), M136 AT4, M136E1, and M141BDM and replace them in the Army arsenal. IAM will provide soldiers with an overmatching lethality against a variety of targets encountered in urban and complex terrain, including hardened targets and field fortifications. With an effective range of 200 meters, IAM will enable the defeat of light armor and personnel located in fortified positions, including masonry structures and earth and timber bunkers. It will be capable of penetrating 30 mm of rolled homogeneous armor (RHA) and a minimum of eight inches of double-reinforced concrete. IAM can be safely fired from within an enclosure or from covered and concealed positions, which is particularly important in supporting the close fight in urban and complex terrain while enhancing soldier survivability.

IAM is particularly well-suited for deployment with infantrymen serving in Infantry, Stryker, and Armored BCTs. As an expendable single-shot disposable weapon, IAM will provide a highly lethal capability that is safe, easy-to-operate, and that can be readily transported anywhere on the battlefield. As a stand-alone, self-contained munition, it requires no maintenance and is not dependent on other systems. IAM development is currently at TRL 5 and could reach TRL 6 by FY2016. The weapon could be fielded by 2021.

2. Small Organic Precision Munition (SOPM) – SOPM is an AMRDEC technology development program to integrate and demonstrate critical component technologies for a soldier-carried, soldier-launched precision-guided loitering munition. Flight demonstrations of system performance are also planned. SOPM is intended to enhance small unit situational awareness, lethality, and survivability in complex environments against combatants on ridgelines, snipers in close urban terrain, and insurgents emplacing IEDs. It's also intended to provide protection for small forward operating bases (FOBs). The munition is designed to reduce collateral damage.

Critical components under development include an image stabilization auto-tracker enabling day/night target acquisition; a digital data link for reliable, secure communications during flight; an integrated warhead, fuze, and proximity sensor to enhance lethality in obscured battlefield environments; and robust power systems for reliable, low-maintenance operation and improved endurance in all temperature environments. Critical components are expected to be at TRL 6 by the end of FY2015. Program plans call for transition to PM Close Combat Weapon Systems (CCWS) and the Lethal Miniature Aerial Munition System (LMAMS) program of record in FY2017.

3. 40mm Extended Range Guided Munition (ERGM) – ERGM is a low-velocity, 40mm munition for use in the M320 Grenade Launcher to be deployed with dismounted troops, including SBCT

infantry rifle companies. The weapon, which features a day/night sight that enables the grenadier to effectively engage the enemy in the dark, currently fires munitions having a maximum range of 400 meters. Employing a higher launch velocity, ERGM will more than double the effective range. Fin stabilization and canards also contribute to extended range, but in addition, provide necessary precision for engagement of point targets. ERGM will provide the warfighter with new capabilities to rapidly engage enemy targets in complex terrains that are difficult to defeat with typical direct-fire KE munitions. It will increase both the probabilities of hit and kill of enemy personnel and crew-served weapon stations. The munition will include a streaming video capability that will enable squad leaders and/or command posts to see threats on the battlefield in real time, at extended ranges and in defilade, to support critical operational and tactical decision-making, and to guide the projectile to its target. The video will also provide an infantry squad with near-real-time battlefield assessment and hit confirmation capabilities. The targeting videos can be uploaded to the Army Battle Command System to support requests for supplemental fires through NETT WARRIOR.

ERGM will incorporate an improved warhead/fuze having three firing modes (airburst, point detonation, and self-destruct), as well as an improved aerodynamic air frame. Rifle squads using the weapon will have the capability to fire air-bursting munitions at greater ranges with improved hit probability by utilizing simplified command guidance and control through a handheld PDA. An alternative configuration for ERGM is also being developed that achieves targeting precision using semi-active laser (SAL) guidance. Once fully developed and deployed, this projectile would be directed to its target by locking onto the reflective energy from a laser designator utilized by the leader or another member of the squad. Further advances involving the guidance system, auto pilot, operator override, and the greening of electronics features, are required to enable ERGM fielding by 2025, all readily achievable if program resources remain available. For the SAL configuration, development of a miniaturized laser receiver and demonstration of its ability to survive high G-forces in a 40mm configuration are required. ERGM is currently at TRL 4, with TRL 6 achievable by the end of FY2016.

4. 120mm High Explosive Guided Mortar (HEGM) – HEGM is an ARDEC tech base program to develop and demonstrate an advanced design for the current unguided M121A1/A2 mortar system that exhibits capabilities greater than achieved for the guided XM395 120mm Accelerated Precision Mortar Initiative (APMI) round. APMI was an accelerated development effort that provided infantry commanders in theater with a precision-strike capability (10-meter circular error probable (CEP)) at a maximum range of 6.2 km. For unguided 120mm M121 mortars, CEP is 136 meters at their maximum range of 7.2 km. APMI, which has had limited fielding to date with IBCT forces, is not a program of record. HEGM will soon become the 120mm precision mortar program of record for the Army. HEGM will provide lower-cost precision (10m CEP) capability for the 120mm system to ranges beyond 7.2 km. It will also incorporate M-code GPS and counter-countermeasures (CCM) features that enable its effective operation against threat defensive systems. Currently at TRL 5, HEGM could be TRL 6 by mid-FY2016.

5. Automated Direct/Indirect Fire Mortar (ADIM) – ADIM is a magazine-fed, 81mm, automated mortar system with multi-role functionality that is intended to provide operational flexibility important to many types of operations, including expeditionary maneuver, attacking targets in defilade, convoy escort, airfield or other fixed-installation overwatch, reconnaissance, assault, and urban combat. It is a lightweight (<2200 lbs combat-loaded), soft-recoil, modular system adaptable for mounting on a variety of light tactical platforms, including light tactical vehicles, towed trailers, and watercraft, and it's capable of both highly responsive direct- and indirect-fire engagements at ranges of 300-6000 meters. It's designed to fire the M821A2 high-explosive mortar round, which has proven effectiveness against personnel, bunkers, and light structures; the M821A2 fuze can be set to function in the proximity, impact, or delay mode.

ADIM is integrated with the fielded M95 MFCS (Mortar Fire Control System), which combines a fire control computer with an inertial navigation and pointing system for greatly improved mortar accuracy and lethality. Its automated aiming, firing, ammunition feed, and diagnostics capabilities enable rounds to be launched within 7 seconds of a call for fires. Indirect fire is cued by a forward observer, either on the ground or airborne. Direct-fire to defeat line-of-sight targets reduces time of flight and expands mission capabilities, compared to conventional mortar systems. With full-time emplacement on a vehicle, and operated remotely to reduce warfighter exposure, ADIM enables a "shoot-and-scoot" operation, which enhances survivability. The system has continuous, 360-degree traverse capabilities, and a rate of fire of up to 30 rounds/minute. Currently at TRL 5, ADIM is projected to be TRL 6 by the end of FY2016.[49]

6. The Advanced Multi-Purpose Munition (AMP) – AMP is a large-caliber (120mm), multi-purpose round (designated XM1069) intended to provide cannon capability against light and medium armor targets, helicopters, massed infantry, and obstacles and barriers. The AMP employs a hardened, combined-effects warhead that provides an advanced breaching capability not currently available to commanders. AMP will provide new capabilities for conducting effective breaching operations at greater standoff; it will be able to create a man-sized hole in double-reinforced concrete walls with only two rounds. Using a data link, the round can also be used in an air-burst mode to generate fragmentation effects out to 3 km against personnel and various materiel targets. In addition, the AMP warhead is being optimized to enable defeat of ATGM launch sites at usual engagement ranges to counter the mass employment of such missiles, which constitute a significant threat to armored and mechanized forces. AMP is also being designed for effective use in direct support of infantry units fighting in urban environments, where collateral damage must be minimized. The baseline AMP has an effective range of about 3 km. An AMP multi-functional concept that employs low-cost course correction (LCCC) technology is being investigated. It will provide a single course adjustment in flight to improve accuracy and extend the effective range against ATGM threats to greater than 5 km. This is particularly critical for attacking ATGM launch sites,

[49] Advanced development efforts are ongoing to give 81mm mortar rounds lethality near 120mm capability through advancements in warhead design and explosives. Also ongoing is an 81mm version of HEGM – intended for use with ADIM – that incorporates the same technology as in the 120mm HEGM round.

as these missiles can easily engage and defeat U.S. armored and other combat vehicles at such ranges. The baseline 120mm AMP is currently at TRL 6+.

The study team believes that the development of a 105mm version of AMP could provide robust capabilities against the same spectrum of targets intended for the 120mm round. Development and fielding of 105mm AMP would enhance the overall effectiveness of 105mm cannons such as on the M1128 Mobile Gun System (MGS) deployed with SBCT forces. A 105mm High Explosive Projectile (HEP) round, the M393A2, currently has the capability to produce man-sized holes in reinforced concrete walls. However, its effectiveness is degraded at ranges greater than about 1,000 meters due to the fuze technology it employs. A 105mm AMP would provide the M1128 MGS system a multi-functional capability in one round, effective against a range of personnel and materiel targets. A baseline 105mm AMP is currently at TRL 5. It could be at TRL 6 by FY2019 if sufficient funds were available to continue its development. Continuing work would include integration of a data link into the M1128 MGS platform to take full advantage of the programmable air-burst feature of AMP. With the addition of LCCC, a 105mm AMP could be matured and demonstrated at TRL 6 by FY2020. Both 120mm and 105mm versions could be available for deployment by 2025.

7. The Mid-Range Munition (MRM) – MRM is a large-caliber (120mm) precision-guided round that will provide the BCT commander the capability to both shape and set conditions in his battlespace that are critical to conducting decisive operations and destroying enemy forces. It will enable effective engagement and defeat of both moving and stationary targets throughout the BCT area of operations. The projectile is intended to meet the need for a beyond-line-of-sight (BLOS) capability to defeat a range of threats with pinpoint accuracy while minimizing collateral damage and reducing exposure of U.S. forces to hostile fire. BLOS fires enable attack of stressing, high-payoff targets at extended ranges and also provide overwatch fires. Such fires allow combat battalion fighting teams and systems to use terrain masking to enhance protection and survivability. MRM will primarily be employed against main battle tanks (MBTs) with explosive reactive armor (ERA) and an active protection system (APS), light and medium armored vehicles, self-propelled artillery, air defense artillery and other high-value targets. Its BLOS range capability of 2-12 km from a stationary platform and 2-6 km from a moving platform complements and reinforces non-line-of-sight (NLOS) fires in the engagement zone. MRM can also be used effectively at shorter ranges, as encountered in urban environments.

The MRM round will incorporate a seeker that enables the munition to attack targets designated via organic or remote (manned/unmanned) sensors, or to attack targets autonomously if designation is lost or not available. The cartridge will have three mission operation modes: autonomous, designate, and designate only, and it will employ autonomous and Semi-Active Laser (SAL) sensors for BLOS engagements. Future Force lethality capabilities will include reactive counter fire conducted by BCTs equipped with organic, networked target acquisition for immediate precise response. Specifically, the MRM round will allow company commanders to set the conditions in offensive, defensive (especially operations in urban and complex terrain), and stabilization and reconstruction operations. It will provide the cavalry battalion commander the capability to mass fires and not forces. Analysis has shown that the

MRM round will provide a significant contribution to force effectiveness, threat overmatch, and survivability. Currently, 120mm MRM is at TRL 6+. For the 105mm application, MRM technology is currently at TRL 5, with TRL 6 achievable by FY2019, subject to availability of resources enabling continuing development.

8. The XM1113 155mm Extended Range Projectile – XM1113 is an artillery cartridge that will enable 155mm 39cal gun systems (e.g., the M777 lightweight, towed howitzer, and Paladin) to achieve effective engagements at ranges of up to 40 km, a significant increase compared to their current 30 km capability. The XM1113 will utilize a high-performance rocket motor design and the Precision Guidance Kit (PGK) previously developed to improve the accuracy of unguided 155mm artillery projectiles. In addition to providing a fuzing function, PGK includes a GPS guidance package and control surfaces that enable in-flight course corrections. PGK has previously been successfully applied to the standard unguided M795 artillery round to achieve near-precision accuracy (CEP < 50m), and M795 with PGK is fielded today. The XM1113 will be at TRL 6 in FY2018 for current 39cal Paladin and M777 towed howitzers. Its near-precision accuracy will reduce the number of projectiles required to engage and destroy targets, providing both logistics and reduced collateral damage benefits.

9. The 155mm Loitering Munition – A concept artillery projectile designed to transform into a powered loitering munition in-flight, following launch, from any 155mm howitzer, without platform modifications. It represents the next-generation targeting, Battle Damage Assessment (BDA) system, and lethal munition. The munition will give the battle commander and other appropriate personnel a quickly-deployable organic sensor-to-shooter asset, able to provide real-time battlefield imagery, enemy target coordinates, and BDA out to 100 km. The munition concept enables simultaneous attacks from multiple directions, thereby eliminating the ability of the target to track the origin of fire. It will increase probability of kill against high-value targets protected with air defense assets by employing effective counter-countermeasures. With this munition, the user will have the ability to receive targeting data while it is in flight to its intended direct and provide redirection as necessary. The munition sensor data will reduce target location error (TLE) and enhance the capability of the shooting platform to achieve lethal first-round effects on target.

The concept 155 mm Loitering Munition will incorporate an optimized warhead payload that exploits advanced warhead geometries and high-yield insensitive munitions (IM) explosives. The combined munition attributes – including rapid deployability, sensor-to-shooter field artillery responsiveness, low-cost, and organic to early entry force – could provide the user with a unique new battlefield capability, contributing to improved targeting effectiveness, survivability, and reduced logistics requirements. Various components of the munition were successfully demonstrated in the early 2000s. With continued development, the 155mm Loitering Munition concept could reach TRL 6 by FY2022. An initial operating capability (IOC) could be achieved by 2030.

10. The Extended Area Protection and Survivability System (EAPS) – EAPS is being developed to provide a counter rocket/artillery/mortar (C-RAM) intercept capability that will deliver

improved performance compared to currently fielded C-RAM systems, as well as a point-protection, counter unmanned aerial systems (C-UAS) capability. It's designed to rapidly sense, engage, target, and destroy incoming RAM rounds, including multiple simultaneous threats, with a kinetic energy (KE) hit-to-kill interceptor. EAPS will provide an affordable, active, miniature (27-28 inches long, 2-inch diameter, lightweight (≤ 5 lbs.)) KE C-RAM/C-UAS interceptor capability that is not currently available.

EAPS also expands miniature hit-to-kill (MHTK) interceptor capabilities with respect to both range and target set. It will provide 360-degree extended area protection over 10X the range of current C-RAM capabilities. Its smaller footprint (compared to current systems) could provide logistics benefits based on reductions in manpower, vehicles, and other ground support equipment. A dual-capable C-RAM/C-UAS integrated missile design is projected to be flight demonstrated and at TRL 6 by the end of FY2016. EAPS could be available for fielding by 2025.

11. Low-Cost Tactical Extended Range Missile (LC-TERM) – LC-TERM is a missile technology development program intended to demonstrate advanced navigation, propulsion, and payload component technologies that (1) reduce the dependence of long-range missiles on GPS guidance; (2) increase range/area coverage; and (3) provide multi-purpose scalable affects against area and point targets. The effort includes development of propulsion technologies that enable target engagement out to approximately 500 km, navigation techniques that enable precision accuracy while reducing dependence on GPS for precision effects, and multi-purpose warhead technologies that enable engagement of point and area targets. LC-TERM seeks to double the operational effectiveness of existing fire units through increased lethality and range, and to enhance accuracy and lethality that creates operational overmatch.

For expeditionary forces, improved range and accuracy in degraded conditions provided by LC-TERM developments could provide a logistics benefit (fewer rounds required to kill targets) while also providing a wider range of fires for the Joint Force Commander. The technology advances being realized on this program have significant applicability to other elements of the fires portfolio. System testing is expected to be at TRL 6 by the end of FY2021. LC-TERM capabilities could be realized in fielded systems by 2030.

12. Tail Controlled GMLRS (TCG) is an AMRDEC program to develop an advanced airframe for the Guided Multiple Launch Rocket System (GMLRS) capable of engaging and defeating targets from 15 km - 150 km, which represents a 2X improvement over GMLRS with respect to maximum range with vertical impact. Effective current GMLRS range with vertical impact is limited to about 70 km, with limited maneuverability for future missions. TCG work involves development of an advanced tail controlled airframe that removes a large majority of the inert weight of the rocket to enhance range and maneuverability, and that has sufficient maneuverability to achieve vertical impact, which enhances GPS delivery accuracy and contributes to reduced collateral damage. It includes fabrication and demonstration of a prototype control actuation system (CAS) for aft packaging, including actuators and

control/drive electronics, as well as a composite GMLRS solid rocket motor (SRM) with blast tube for packaging the aft control kit.

CAS and SRM developments are expected to have applicability to LC-TERM. TCG flight demonstrations are planned for late in FY2016. The advanced capabilities of Tail Controlled GMLRS could be fielded by 2025.

13. The Advanced Remote/Robotic Armament System (ARAS) – ARAS is an ARDEC .50 cal remote weapon system development that reflects continuing efforts to integrate automation into weapon systems. It combines lethality, survivability, and multi-role functionality into a compact system that provides soldiers with a .50 cal machinegun weapon having improved accuracy and scalable effects, from non-lethal to lethal, while also enhancing safety and survivability. ARAS full-spectrum capabilities allow soldiers to adapt to missions ranging from offensive engagements, to civil support, to authority operations. It can contribute to enhanced battlefield effectiveness by eliminating the need for soldiers to carry multiple weapons and to re-tool their weapon systems in transitioning from lethal to non-lethal operations. Both of these features provide a logistical benefit. ARAS can be mounted on a variety of platforms, either mobile or fixed. Mounted to a fixed station, it can provide support to forward operating bases, command observation posts, and patrol bases. It can also support the robotic wing-man concept for convoys. A robotic convoy vehicle integrated with this remote weapon system can scan and designate hostile targets. The system simultaneously provides convoy commander situational awareness, facilitating direct action against threat targets without the main body becoming engaged in the conflict. With minor modifications, ARAS has the ability to contribute to Army Aviation requirements for arming utility rotary aircraft to increase their survivability during hostile operations. Because the system is automated, pilots can control it to address enemy targets through their helmets, reducing the need for door gunners.

ARAS includes: (1) an accurate .50 cal externally powered weapon capable of firing lethal and blunt trauma non-lethal ammunition; (2) an all-weather capable sight package that includes day/night sights, thermal sights, and a laser range finder; (3) an Integrated ammunition handling system for automatic ammo reload, ammo storage, and under armor resupply; (4) a high performance turret for accurate aiming, improved stabilization, fast slew rates, and a target hand-off hunter/killer capability; (5) 90-degree weapon elevation for engaging targets in urban and mountainous terrain; (6) variable firing from single shot (precision mode) to full auto suppressive fire; and (7) a dual-feed lighter weight variant applicable to aviation platforms. ARAS development is currently at TRL 5, with TRL 6 achievable by FY 2016 depending on the specific application.

In addition to the selected precision munitions and advanced weapons programs described above, there are numerous, other ongoing technology development efforts that can be expected to make significant contributions toward enhancing the capabilities of expeditionary forces by 2025 and beyond. Relevant activities involve advanced sensors, terminal guidance, lethal mechanisms, advanced warhead materials and designs, navigation and control, data links, fire control, propulsion, higher performance energetics, and advanced proximity fuzing. More specific activities include technologies important to the development of effective counter-countermeasures, low-recoil conventional guns/cannon, collaborative munitions that can communicate with each other to increase overall targeting effectiveness, gun-launched sensors to provide organic situational awareness capabilities, extended range loitering, more lethal artillery munitions, advanced wall-breaching/demolition munitions, and enhanced sniper weapon systems. A detailed review and assessment of these activities is beyond the scope of this study, however, two such activities merit special attention:

1. Advanced Warheads for Scalable Effects Munitions (AWSEM) – AWSEM is a collaborative ARDEC/ARL/AMRDEC research effort intended to lead to the development of advanced warhead technologies that will provide more lethal and tailorable effects, and to transition these technologies to appropriate weapons development and demonstration programs. Its goals include development of smaller and lighter warheads with increased lethal effects and an increased range of outputs (ranging from lethal to less-than-lethal); advancement of component technologies for novel explosively formed projectiles (EFPs), shaped charges, and blast/frag warhead designs (i.e., by exploiting novel materials, high-energy-density insensitive energetics, novel initiation systems, nano-materials, and synergistic effects); and identification and mitigation of geometry and scaling issues that currently limit the performance of small-diameter or asymmetric warhead designs. Expected payoffs include new munitions that will provide warfighters with tactical overmatch (tailorable and decisive effects); reduce the logistics, sustainability, transportability and physical burdens with lighter and smaller munitions; improve force protection and survivability (fewer and smaller munitions with less explosives); and capabilities ranging from highly lethal, to less-than-lethal in a single munition. Many of the technological developments being pursued on the AWSEM program are expected to be at TRL 6 or beyond by 2020.

2. Micro-Technology for Positioning, Navigation and Timing (micro-PNT) – A DARPA program to develop advanced technology for self-contained, chip-scale, inertial navigation and precision guidance that would effectively eliminate the dependence on GPS or any other external signals and enable uncompromised navigation and guidance capabilities for advanced munitions, mid- and long-range missiles, and various military platforms, including UAVs, under a wide range of operating conditions. The miniaturized, lightweight, low-power, and cost-effective PNT devices under development will serve to eliminate a significant potential vulnerability for many DoD systems where intended targets are either equipped with high-power jammers or GPS information is compromised, whether as a result of some type of component or overall system malfunction, or as a consequence of deliberate enemy action. The micro-PNT program includes three principal thrust areas: (1) ultra-precision timing devices, (2) inertial sensors, and (3) microscale integration. Specific efforts include development of new fabrication techniques, deep integration, and on-chip self-calibration. The effective application of micro-PNT devices to a range of Army weapon systems will have a profound impact on the targeting capabilities of precision munitions and other advanced weapons for both expeditionary and follow-on forces.

6.6 ANTI-MISSILE AND ADVANCED DIRECTED ENERGY

High energy lasers offer the potential for:

- Speed-of-light delivery of lethality to the target
- Graduated engagements from disrupt to destroy
- Precision Strike—minimum collateral damage, low fratricide
- Multiple, low-cost shots—large number of kills per platform

Recent advances in solid-state laser technology will permit development of more compact, higher-power systems for Army applications. For example, Space and Missile Defense Command (SMDC) is developing the High Energy Laser Mobile Demonstrator (HEL MD) to show directed energy force protection capabilities against rockets, artillery, mortars, unmanned aerial vehicles, and cruise missiles. Recent lethality demonstrations use a 10 kW solid-state laser mounted on a Heavy Expanded Mobility Tactical Truck (HEMTT). Upgrades to 50 kW and then 100 kW lasers are planned as improved lasers become available.

HPM systems offer potential for:

- Speed-of-light, all-weather attack of enemy electronic systems
- Area coverage of multiple targets with minimal prior information on threat characteristics.
- Minimum collateral damage in politically sensitive environments
- Simplified pointing and tracking
- Deep magazines and low operating costs
- Nonlethal antipersonnel weapon applications

DoD has tasked the Services to develop systems that render the enemy inoperative while minimizing collateral damage. For example, the Air Force was granted a HPM Institute under the Air Force Research Laboratory's Directed Energy Directorate. The Navy has developed tools to model the vulnerability and susceptibility of its shipboard electronic systems, subsystems, and components to HPM weapons. Recent Army efforts have focused on defeating improvised explosive devices.

6.7 DEPLOYABLE WATER TREATMENT AND PURIFICATION

The study team's review of technology required to produce water from air, and to treat gray water, shows that both are at TRL 6 today. A decision to enter into EMD phase on selected platforms is now required. The technology is understood, but integration into Army operations needs to be accomplished. It is reasonable to expect that within the limitations of the acquisition process and current funding constraints, there is not a technical barrier to having both capabilities for small units in the 2025 time frame. If the Army desired, it could be done under Rapid Acquisition rules before 2025.

6.8 ADVANCED MATERIALS AND MANUFACTURING

The Army is under increased pressure to deliver improved parts featuring corrosion resistance, wear resistance, lower weight, and a smaller component footprint. Demands for faster, lighter, and enhanced life cycle of equipment are a major challenge for Army devices and equipment. In many cases this requires special alloys, titanium alloys, and powder metal alloys. For expeditionary maneuver, lightweight materials are of paramount importance. Polymer composites can be processed and fabricated into lightweight, structurally sound parts and components that improve logistic lift burdens and war-fighter performance. For example, composites can be used for pallets and decking that increase mobility in harsh environments. In addition, these materials can be used to create low-cost protection against shrapnel and small arms fire. Some of these materials can even be used to create stealth coatings.

New advances in manufacturing, specifically, 3D Printing or Additive Manufacturing methods, have great potential as game changers**.** Starting in the late 1980s, several new manufacturing technologies were created that have the potential to revolutionize manufacturing. These technologies are, for the most part, additive processes that build up parts layer by layer. The processes that are being touted for hard-core manufacturing are primarily laser or e-beam based processes. This technology initially grew out of a commercial need for rapid prototyping and is just now starting to penetrate the manufacturing market. Improved machine sensors, materials, and operational methods are used today to enable manufactured parts. These 3D Printing techniques, although still maturing, have the potential to enable short run production that can be done in theater. This capability could dramatically shorten supply chains by producing spare parts at the deployed location and allow innovative parts to be designed and produced in real-time as needed.

6.9 FUEL CELLS, BATTERIES, AND SOLAR PHOTOVOLTAICS

Low temperature (less than 100 degrees C) fuel cells provide lower thermal and noise signatures than conventional generators, an alternative that can be useful in hostile areas. They are also very efficient, consuming less fuel than conventional generators. Systems that run on jet fuel have also been developed. Fuel cells are currently being installed on bases in the US and deployable systems have been tested in Afghanistan. The Corps of Engineers Engineer Research and Development Center (ERDC) has several demonstration projects underway at military installations around the country, which include fuel cells ranging from 200 watts to more than 250 kilowatts (kW) per unit.

The Communications-Electronics Research, Development, and Engineering Center (CERDEC) is also pursuing advances in power generation, energy storage, and power management components. These include smaller, lighter, hybrid, and renewable (battery/engine/wind/solar) energy and co-generation equipment. To manage times when wind or solar are not available, an integrated power management system controls energy generation and storage.

6.10 THERMOELECTRIC HARVESTING OF WASTE HEAT GENERATION

The Natick Soldier Research, Development and Engineering Center (NSRDEC) is working on mechanisms to harvest energy from a wide spectrum of electromagnetic wavelengths, including infrared, and using a technology called “rectennas” (rectifying antennas). A simple rectenna element consists of a dipole antenna with an RF diode connected across the dipole elements. The diode rectifies the alternating current induced in the antenna by the microwaves, to produce DC power, which powers a load connected across the diode. The same principle works with EM energy at different wavelengths, including infrared.

The NSRDEC work is in its early stages. The efficiency of such a system (i.e., how much electrical energy can be captured, divided by the total amount of energy incident on the rectenna) is currently very low, less than 1%. But just as happened with solar photovoltaics, where energy efficiency started very low and then grew substantially with additional R&D, the same progress is expected with this technology as well.

Rectennas operating across a wide spectrum of wavelengths offer the potential to harvest energy day and night, regardless of weather conditions. Since a considerable amount of waste energy comes in the form of infrared emissions from motors and power plants, either as a result of friction or thermodynamic cycle considerations, the prospect of being able to harvest some of this energy and convert it into electricity promises two potential benefits: (1) additional energy recovery; and (2) reduced infrared emissions from the target source. One can envision a hemispherical array of rectennas surrounding an infrared source to achieve this purpose.

6.11 CONCLUSIONS

The study team compared each of the technology areas discussed above to the key conclusions from Unified Quest 2013 to see how relevant they were to addressing the needs of the Army. The results of those comparisons are captured in the two tables below.

Unified Quest Goals and Results	Automated offensive and defensive cyber	Stealthy, swarming, micro, cross-domain UAVs; automated platforms	Sense-making data fusion, wide-area ATR	Fusion of LIDAR and EO sensors, Green-sensitive camera, Air-cooled laser
Swiftness of action must be balanced with security, survivability, and sustainability	X	X	X	X
Reduce predictability with multiple entry points	X	X	X	X
Dominate the human domain to shape the environment and set conditions	X			
Network protection is critical; offensive methods had limited effects on the plan	X	X		
Formations, capabilities, mobility of sustainment forces can limit speed, agility, and endurance	X	X	X	X
Fuel consumption and lack of host nation support is realistic challenge	X	X		X
Mass effects to create shock through cross-domain dominance and integration	X	X	X	
Rapidly aggregate/disaggregate combinations of Army and Unified Action Partners	X	X	X	
Sustain agile operations	X	X	X	X
Deter use or proliferation of WMD	X	X	X	X
Promote intervention legitimacy	X	X	X	X
Deter civilians from interfering with operations	X	X	X	X
Degrade paramilitary and terrorist capabilities	X	X	X	X

Figure 6.6 Beyond 2025 Technologies Supporting Unified Quest 2013 Objectives (1 of 2)

Unified Quest Goals and Results	Precision fires/ precision munitions (miss distance in cm)	Anti-missile, directed energy	Deployable desal'n, water treatment and purification	Advanced high-performance materials	Fuel Cell, Scaling up Zn-air, 45% efficiency PV	Thermoelectric on waste heat
Swiftness of action must be balanced with security, survivability, and sustainability	X	X	X	X	X	X
Reduce predictability with multiple entry points						
Dominate the human domain to shape the environment and set conditions			X			
Network protection is critical; offensive methods had limited effects on the plan	X					
Formations, capabilities, mobility of sustainment forces can limit speed, agility, and endurance	X	X	X	X	X	X
Fuel consumption and lack of host nation support is realistic challenge			X	X	X	X
Mass effects to create shock through cross-domain dominance and integration		X		X		
Rapidly aggregate/disaggregate combinations of Army and Unified Action Partners						
Sustain agile operations	X	X	X	X	X	X
Deter use or proliferation of WMD	X	X				
Promote intervention legitimacy	X					
Deter civilians from interfering with operations						
Degrade paramilitary and terrorist capabilities	X	X				

Figure 6.7 Beyond 2025 Technologies Supporting Unified Quest 2013 Objectives (2 of 2)

7.0 SUMMARY

7.1 ENHANCEMENT OPPORTUNITIES

Six key areas impact enhancements to maneuver capability:

1. Water
2. Fuel
3. Ammunition
4. Footprint
5. Time to Deploy
6. Lethality/Survivability

The first three impact areas correspond to 38% of the tonnage of an SBCT, plus 30 days sustainment. Reducing the amount of materiel in these categories will enhance expeditionary maneuver. Furthermore, a number of enablers that also enhance expeditionary maneuver can be developed now without new program starts (Figure 7.1). These enablers could begin to show payoff in the very near term. Note the proposed new contracting paradigm to build commercial partnership capabilities.

Enablers	Primary Areas of Impact
Decompose TOE capabilities to enable a planning database linking subordinate organizations with required force enablers	Time, Lethality/Survivability
More existing precision fires/munitions, fewer dumb rounds, especially with early entry forces	Lethality/Survivability
Use Live Virtual Constructive (LVC) simulations for preliminary evaluation of concepts	All
Develop plans/new contracting paradigms to enable *contracting at the speed of expeditionary maneuver*:	
• Leverage commercial sealift - Mobile prepo at sea	Water, Fuel, Time
• Leverage commercial airlift - Account for LD3 containers in unit outload	Water, Ammo, Time
• Leverage in-area sources of water (e.g., bottling plants)	Water, Time
• Exploit existing commercial communications in area of operation (e.g., cellular network)	Time, Footprint
• Exploit existing commercial power supplies in area of operation (electrical, fuel)	Fuel, Time, Footprint

Figure 7.1 Current Enablers Not Requiring New Programs

Throughout the course of the study, study team members have also identified, discussed and nominated several other enablers the team believes can be demonstrated by 2020 (Figure 7.2). These include unmanned aerial and ground vehicles, as well as energy-saving and energy-efficient technology.

Enablers	Primary Areas of Impact
Capability-Based Deployment Planning simulation and models	Time, Lethality/Survivability
Small unit mobile devices for ISR and SA	Lethality/Survivability
Exploit commercial developments to better utilize the ubiquitous information environment	Water, Fuel, Ammo, Time, Footprint, Lethality/Survivability
Expand use of existing UAVs for ISR, aerial net, targeting	Footprint, Lethality/Survivability
Cargo movement by UAV (light-to-medium), precision airdrop	Water, Fuel, Ammo, Time, Footprint, Lethality/Survivability
Improved ISR (sensors, LIDAR, other technologies)	Lethality/Survivability
Improved photovoltaic energy harvesting (structures, vehicles, ultimately soldier uniforms)	Fuel, Footprint
Selected counter-digitization effects	Lethality/Survivability
Semi-autonomous UGVs	Water, Fuel, Ammo, Time, Footprint, Lethality/Survivability
Improved energy harvesting (non-photovoltaic) – e.g., rectennas, mechanical	Fuel, Footprint
Directed energy weapons (RF, laser)	Time, Lethality/Survivability
Laser communications	Time, Footprint
Improved energy storage (batteries)	Footprint
Internet of Things (sensors on vehicles, weapons systems to report operational status over Internet) (requires security paradigm) ; also, improved authentication of systems, and easier encryption for data transport and storage	Time
Use commercially available higher efficiency engines in vehicles	Fuel, Time, Footprint
Use available higher efficiency engines in rotorcraft	Fuel, Time, Footprint

Figure 7.2 Enablers Demonstrated by 2020

7.2 FINDINGS

The ASB study team developed thirteen findings based on data gathered during the study:

1. Proliferation of A2/AD threats affects early entry operations significantly; conventional approaches involving the massing of forces in predictable ports of debarkation are especially vulnerable
2. CONUS basing and/or austere conditions severely constrain force size that can be deployed during initial entry
    - Tailoring of forces and sustainment to maximize mission effectiveness of initial entry forces becomes critical under either condition
    - In certain circumstances, availability of Joint capabilities can free up capacity for other, high-priority Army capabilities (medical services, fire support, ISR)
3. Mission command is critical to expeditionary maneuver; historical overmatch in this area is eroding with the advent of social media and the ubiquitous spread of information technology
4. Vertical lift is an essential enabler for Synchronized Distributed Interdependent Maneuver via unpredictable entry points
5. Cyber and other digital systems will be increasingly subject to exploitation, denial, deception, and negation in 2025, exacerbated by reliance on commercial capabilities; offers both opportunities and challenges for strategic and expeditionary maneuver

6. Stovepipes resulting from Title 10 vs. Title 50 authorities disallow tactical exercises in the US that employ Title 50 systems; impede warfighting functions critical to expeditionary maneuver
7. Mega-cities will confront the Army with new challenges requiring specialized and intensive pre-planning, advanced analytics, and regular training; must operate in three-dimensional urban terrain, with intermingled adversaries and non-combatants, employing complex rules of engagement applied to a highly dynamic environment
8. By 2025, commercial advancements in many key areas will outpace those driven by the Army and DoD; among others, mobile communications, cargo aircraft and ships, and commercial information technology can enhance significantly strategic and expeditionary maneuver
9. By 2025, DoD-sponsored advancements in selected areas will have matured to the point where they can be incorporated into Army operations; semi-autonomous systems, hybrid-powered platforms, aerial layer communications and networking, precision fires/munitions all hold promise for reducing logistics burden
10. Beyond 2025, DoD-sponsored advancements in additional selected areas will have matured to the point where they can be incorporated into Army operations; unmanned vertical heavy lift (25-30 ston payload), advanced directed energy weapons, etc.
11. Globalization may provide an opportunity to harness resource availability around the world (e.g., bottling plants, cellular providers); offsets logistics burden by taking advantage of indigenous resources
12. Partnering with other nations, non-governmental organizations, and commercial entities can enhance regional stability and may enable additional options for prepositioning, stationing, and sustainment support; critical in austere and/or unfamiliar environments
13. Navy FY15 POM eliminates National Defense Sealift Fund, used in past to maintain surge sealift[50]
    - Funding transferred to Navy O&M Ready Reserve Force ($291M) and Ship Pre-positioning and Surge ($106M) accounts
    - Contrary to prior Army/Navy agreements

7.3 RECOMMENDATIONS

Based on these findings, the ASB study team makes the following recommendations for actions by Army leadership:

CSA: Advocate for maintaining National Defense Sealift Fund to sustain capability for surge sealift; coordinate with Joint community[51]

ASA(ALT):

- Ensure key technologies (e.g., semi-autonomous systems, hybrid-powered platforms, aerial layer communications and networking, precision fires/munitions) are addressed in BA4, BA3 (and BA2) funding plans

[50] See footnote 2 above.
[51] Ibid.

- In coordination with USTRANSCOM, AMC, G3/5/7, G4, and DLA: Develop the strategy and business case to exploit commercial assets for transportation, acquisition of supplies, and communications for the expeditionary force; consider new and improved vehicles to enable "contracting at the speed of expeditionary maneuver"

CG FORSCOM:

- With support from G3/5/7: Develop capability-based planning tools with sufficient granularity (company level and below) to optimize early entry force effectiveness and leverage joint capabilities (fire support, ISR, medical services) whenever possible; accelerate and expand Global Force Management Data Initiative to meet this purpose
- Execute Emergency Deployment Readiness Exercises (EDREs)

CG TRADOC:

- Develop and conduct Joint Concept Technology Demonstrations (JCTDs) and/or warfighting experiments for each of the four concepts identified in this study
- Integrate the most promising concepts in end-to-end experiments
- Evaluate BCT force structure to determine if current force design supports expeditionary distributed operations using smaller units (company level and below)
- In coordination with G3/5/7, G2, and G6: Develop doctrine, training, TTPs, and technical capabilities to integrate kinetic, cyber, and electronic warfare effects as an organic BCT tactical capability to be incorporated in all operational planning; new approach to combined arms
- Develop integrated and interdependent CONOPS and evaluate operational utility for distributed maneuver using near-term non-developmental items (NDIs) for vertical lift and precision airdrop; initiate requirements assessment for a future unmanned heavy lift vertical system for JLOTS and mounted vertical maneuver

Director ARCIC: In coordination with RDECOM: Beginning with concepts identified in this study, conduct detailed DOTMLPF analysis on concepts and enablers by end of 2015

G3/5/7:

- Set requirement to reinstitute Emergency Deployment Readiness Exercises (EDREs)
- Review readiness issues resulting from Title 10/Title 50 authorities and, as required, articulate path forward to remove constraints on CONUS-based BCT training with Title 50 systems
- Designate a specialized BCT testbed for expeditionary urban operations to develop doctrine and training required for operating in mega-cities; leverage Army National Guard presence in US mega-cities for relevant civilian skillsets
- In coordination with USTRANSCOM, AMC and DLA: Expand concepts for strategic partnering to leverage partner contributions (including logistics) in future operations
- With G4 and TRADOC: Review sustainment planning factors for deployment in expeditionary maneuver

CG Maneuver COE: With support from CG Cyber COE: Make counter-digitization part of the maneuver, fire, and effects warfighting function

APPENDIX A: ABBREVIATIONS AND ACRONYMS

A2/AD	Anti-Access Area Denial
ABCT	Armored Brigade Combat Team, previously HBCT
ABI	Activity Based Intelligence
ASCC	Army Service Component Command
ACTD	Advanced Concept Technology Demonstration
ADIM	Automated Direct/Indirect Fire Mortar
AMC	Army Materiel Command
AMP	Analysis of Mobility Platform model
AMP	Advanced Multi-Purpose (Munition)
AMRDEC	Aviation & Missile Research Development and Engineering Center
AOS	Army Organizational Server
APMI	Accelerated Precision Mortar Initiative
APOD	Air Port of Debarkation
APOE	Air Port of Embarkation
APS	Active Protection System
ARAS	Advanced Remote/Robotic Armament System
ARCIC	Army Capabilities Integration Center – supports CG TRADOC
ARDEC	Armament Research Development and Engineering Center
ARL	Army Research Laboratory
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
ASC	Army Sustainment Command
ATGM	Anti-Tank Guided Missile
ATR	Automatic Target Recognition
BA#	Budget Area number
BCT	Brigade Combat Team - the Army's basic tactical formation (see ABCT, HBCT, IBCT, SBCT)
BDA	Battle Damage Assessment
BLOS	Beyond Line of Sight
C-RAM	Counter-Rocket/Artillery/Mortar
C-UAS	Counter Unmanned Aerial System
C2	Command and Control
C3I	Command, Control, Communications, Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance
CAA	Center for Army Analysis
CAS	Control Actuation System
CASCOM	Combined Arms Support Command, Ft Lee, VA
CBRN	Chemical, Biological, Radiological, Nuclear
CBRNE	Chemical, Biological, Radiological, Nuclear, High Yield Explosive
CCM	Counter-countermeasure
CCMD	Combatant Command
CEP	Circular Error Probable
CERDEC	Communications - Electronics Research Development and Engineering Center
CG	Commanding General
CAN	Center for Naval Analysis
CNR	Combat Net Radio
COE	Center of Excellence
CONOPS	Concept of Operations
CONUS	Contiguous United States (does not include Alaska or Hawaii)
COTS	Commercial Off The Shelf

CPU	Central Processing Unit (computer)
CRAF	Civil Reserve Air Fleet
CSA	Chief of Staff of the Army
DE	Directed Energy
DLA	Defense Logistics Agency
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities
DRRS	Defense Readiness Reporting System
DRRS-A	Defense Readiness Reporting System-Army
EAPS	Extended Area Protection and Survivability
ECCM	Electronic Counter-Countermeasures
EDRE	Emergency Deployment Readiness Exercise
EMS	Electromagnetic Spectrum
ERA	Explosive Reactive Armor
ERGM	Extended Range Guided Munition
ERP	Enterprise Resource Planning
ESB	Engineer Support Battalion
EW	Electronic Warfare
FFRDC	Federally Funded R&D Center (e.g., CNA, IDA, MITRE, RAND)
FOB	Forward Operating Base
FORSCOM	US Army Forces Command
FVL	Future Vertical Lift
GCS	Ground Combat System
GFM-DI	Global Force Management – Data Initiative
GMLRS	Guided Multiple Launch Rocket System
GOTS	Government Off The Shelf
GPS	Global Positioning System
HADR	Humanitarian Assistance Disaster Relief
HBCT	Heavy Brigade Combat Team, now ABCT
HEGM	High Explosive Guided Mortar
HEP	High Explosive Projectile
HNW	High-band Network Waveform
HPC	High Performance Computing
HUMINT	Human Intelligence
IAM	Individual Assault Munition
IARPA	Intelligence Advanced Research Projects Agency
IBCT	Infantry Brigade Combat Team
IC	Intelligence Community
ICD	Initial Capabilities Document
IDO	Integrated Distributed Operations
IED	Improvised Explosive Device
IM	Insensitive Munitions
IOC	Initial Operating Capability
IoT	Internet of Things
ISB	Intermediate Staging Bases
ISIL	Islamic State of Iraq and the Levant (also known as ISIS)
ISIS	Islamic State of Iraq and Syria (also known as ISIL)
ISO	International Organization for Standardization
ISR	Intelligence, Surveillance, Reconnaissance
JALN	Joint Aerial Layer Network
JCEO	Joint Concept for Entry Operations

JCIDS	Joint Capabilities Integration Development System - DoD procedure which defines acquisition requirements and evaluation criteria
JCS	Joint Chiefs of Staff
JCTD	Joint Concept Technology Demonstration
JFAST	Joint Flow and Analysis System for Transportation - Model that determines the transportation feasibility of a course of action or operation plan; provides daily lift assets needed to move forces and resupply; advises logistic planners of channel and port inefficiencies; and interprets shortfalls from various flow possibilities.
JHL	Joint Heavy Lift
JIIM	Joint, Interagency, Intergovernmental, Multinational
JLOTS	Joint Logistics Over The Shore
JMR-TD	Joint Multi-Role – Technology Demonstration
JOA	Joint Operation Area
JOAC	Joint Operational Access Concept
JOPES	Joint Operation Planning and Execution System
K-Max	Helicopter built by Kaman – crew of one (also remote controlled)
KE	Kinetic Energy
LC-TERM	Low-Cost Tactical Extended Range Missile
LCCC	Low Cost Course Correction
LIA	US Army Logistics Innovation Agency
LogCAP	Logistics Civil Augmentation Program
LOS	Line Of Sight
LVC	Live, Virtual, Constructive (simulations)
MASINT	Measurement and Signature Intelligence
MBT	Main Battle Tank
MCOE	Maneuver Center of Excellence (Ft. Benning, GA)
MCOTM	Mission Command On-The-Move
MFCS	Mortar Fire Control System
MGS	Mobile Gun System
MHTK	Miniature Hit-to-Kill
MI	Military Intelligence
MOE	Measure of Effectiveness
MOG	Maximum (aircraft) On Ground (measure of capacity of airfield)
MRM	Mid-Range Munition
MVM	Mounted Vertical Maneuver
NDI	Non-Developmental Item
NGA	National Geospatial-Intelligence Agency
NGO	Non-Governmental Organizations
NIE	Network Integration Evaluation
NLOS	Non-Line-of-Sight
NSRDEC	Natick Soldier Research Development and Engineering Center
O&M	Operations and Maintenance
OA	Operating Area
OPCON	Operational Control
OTH	Over-The-Horizon
OTM	On-The-Move
PDA	Personal Digital Assistant
PEO-EIS	Program Executive Office - Enterprise Information Systems
PGK	Precision Guidance Kit
PNT	positioning, navigation, and timing
POD	Port of Departure

POE	Port of Embarkation
POM	Program Objective Memorandum – budget submission form Services to OSD
POR	Program of Record
R&D	Research and Development
RAF	Regionally Aligned Force
RDECOM	Research, Development, and Engineering Command
ROMO	Range of Military Operations
SA	Situational Awareness
SAL	Semi-active laser
SATCOM	Satellite Communications
SBCT	Stryker Brigade Combat Team
SDDC TEA	US Army Surface Deployment and Distribution Command Transportation Engineering Agency (component of USTRANSCOM)
SDIM	Synchronized Distributed Interdependent Maneuver
SIGINT	Signals Intelligence
SINCGARS	Single Channel Ground and Airborne Radio System
SOF	Special Operations Force
SOPM	Small Organic Precision Munition
SPOD	Sea Port of Debarkation
SPOE	Sea Port of Embarkation
SRC	Standard Requirements Code (9-digit code)
SRM	Solid Rocket Motor
SRW	Soldier Radio Waveform
Ston	Short ton (2,000 lb)
TAA	Tactical Assembly Area
TACON	Tactical Control
TARDEC	Tank Automotive Research Development and Engineering Center
TCG	Tail-Controlled GMLRS
TEU	Twenty-foot Equivalent Unit (container – approximately 20 ft x 8 ft x 8.5 ft high)
TLE	Target Location Error
TOC	Tactical Operations Center
TOE	Table of Organization and Equipment
TPFDD	Time-Phased Force Deployment Data
TRADOC	Training and Doctrine Command
TRANSCOM	US Transportation Command – provides air, land, and sea transportation for DoD
TRL	Technology Readiness Level (see table below)
TTP	Tactics, Techniques and Procedures
TUCHA	Type Unit Characteristics File
UAS	Unmanned Aerial Systems (also Unmanned Aerial Vehicle – UAV)
UGV	Unmanned Ground Vehicle
UIC	Unit Identification Code
UN	United Nations
UQ	Unified Quest – ARCIC annual study to identify challenges and opportunities for the future force
USG	US Government
USMC	United States Marine Corps
USN	United States Navy
UTC	Unit Type Code
VCSA	Vice Chief of Staff of the Army
WIN-T Inc3	Warfighter Information Network – Tactical Increment 3
WMD	Weapon of Mass Destruction (CBRNE)

TRL Definitions[52]

	DEFINITION	DESCRIPTION
TRL1	Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.
TRL2	Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
TRL3	Analytical and experimental critical function and/or characteristic proof-of-concept.	Active R&D is initiated. This includes analytical studies and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
TRL4	Component and/or breadboard validation in a laboratory environment.	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
TRL5	Component and/or breadboard validation in a relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.
TRL6	System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.
TRL7	System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment (e.g., in an aircraft, in a vehicle, or in space).
TRL8	Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation (DT&E) of the system in its intended weapon system to determine if it meets design specifications.
TRL9	Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation (OT&E). Examples include using the system under operational mission conditions.

[52] From DoD Technology Readiness Assessment (TRA) Guidance, published by the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)); April 2011.

APPENDIX B: TERMS OF REFERENCE

SECRETARY OF THE ARMY
WASHINGTON
MAR 1 1 2014

Mr. George Singley
Chairman, Army Science Board
101 Army Pentagon
Washington, DC 20310

Dear Mr. Singley:

I request that the Army Science Board conduct a study titled, "Decisive Army Strategic and Expeditionary Maneuver." The Board last studied strategic maneuver in 1999 with an effort titled, "Enabling Decisive Strategic Maneuver for the Army Beyond 2010." This study helped inform a number of subsequent decisions, however, the Army has since conducted the Army After Next studies, created the Objective Force Task Force, developed and equipped the 4th Infantry Division with the Stryker, initiated the Future Combat Systems program, made plans for a new Ground Combat Vehicle, and acquired vast lessons learned from over 10 years of operations in Iraq and Afghanistan. Since 1999, the capability to deliver an operationally relevant force in a timely manner has remained stagnant or decreased.

The most recent National Security Strategy describes a pivot to the Pacific. The Air Force and Navy have announced their Air Sea Battle concept, and the Department of Defense is placing priority on the "Asia pivot" and countering threat anti-access/area-denial (A2AD) methods. The recent Army Unified Quest Exercise stressed the need for the Army to be able to perform rapid, timely, decisive maneuver to Asia, the Middle East or other areas of the globe. While the Department of Defense strategy focuses on Asia, the challenge the Combatant Commander and the Army face is the ability to respond rapidly to accelerating events in a Joint A2AD environment.

The concepts of Strategic and Expeditionary Maneuver are defined as follows:

a. Strategic Maneuver: The agile posturing and employment of forces and capabilities, in all domains on a global scale, to gain and maintain physical, temporal and psychological advantage over potential adversaries.

b. Expeditionary Maneuver: The rapid deployment of scalable or tailored operationally and tactically significant forces on short notice to austere locations in order to conduct any type of operation immediately upon arrival, often in persistent A2AD environments. Expeditionary Maneuver exploits the knowledge, access and advantages gained through strategic maneuver to achieve strategic objectives and restore strategic balance.

- 2 -

The purpose of this study is threefold:

a. Identify challenges that may compromise operational forces' ability to successfully conduct strategic and expeditionary maneuver in 2025, assuming no more military strategic air and sea lift than in the force today. The study will recommend innovative advanced concepts to meet the challenges identified. The study will also identify critical technologies, systems and/or processes that might serve as enablers. It is expected that the study will produce approximately three to five concepts to be assessed through Army warfighting experimentation.

b. Explore options the Army can leverage in joint air- and sea-based capabilities, commercial capabilities and partnering opportunities to improve strategic and expeditionary maneuver in 2025, recognizing Combatant Commander responsibilities.

c. Identify, for 2025 and beyond, Army, other Department of Defense, other U.S. Government, industry (defense and commercial), as well as university and Federally Funded Research and Development Centers research, technology, engineering and innovations that could improve the Army's capabilities for strategic and expeditionary maneuver. The study will evaluate these enablers in light of the Unified Quest 2013 results and include consideration of relevant science and technology.

The Commanding General, U.S. Army Training and Doctrine Command is the sponsor of this study. Provide a briefing with all findings and recommendations by September 30, 2014. Provide the final written report by October 31, 2014. The briefing and report will offer actionable recommendations. The study will operate in accordance with the Federal Advisory Committee Act and Department of Defense Directive 5105.4 (Department of Defense Federal Advisory Committee Management Program.) It is not anticipated that this study will need to go into any particular matters regarding the interpretation of United States Code, nor will it cause any member of the study team to be placed in the position of acting as a procurement official.

Sincerely,

John M. McHugh

John M. McHugh

APPENDIX C: STUDY TEAM MEMBERS

The 2014 ASB Strategic and Expeditionary Maneuver study consisted of the following members and support staff:

Dr. Jeff Isaacson, Chair

Dr. Gisele Bennett, Vice-Chair

Dr. Joe Beaman	MG(ret) Charles Henry
Dr. Nancy Chesser	RADM(ret) Grant Hollett
Dr. John-Paul Clarke	Dr. Mike Macedonia
Mr. William Crowder	GEN(ret) David Maddox
Dr. Endy Daehner	Dr. Allan Mense
Dr. Mark Glauser	Dr. Ronald Sega, MG(ret)
Mr. Richard Guida	Dr. William Snowden
Mr. Mike Heinz	Dr. Buck Tanner

LTC Drew Warninghoff, Study Manager

Maj Todd Willert, Study Manager

Mark Swiatek, Tech Writer/Editor

APPENDIX D: LINES OF INQUIRY AND VISITATIONS

Combatant Commands (CENTCOM, SOCOM, and TRANSCOM), Army Service Component Commands (USARPAC, USAREUR), FORSCOM, CEO, and AUSA

1. What 'Regionally Aligned Force' activities are being accomplished and being planned?
2. What are the benefits of Regionally Aligned Forces?
3. What activities do you perform (or plan) in any regionally aligned areas during peacetime?
4. What activities do you need to have accomplished to maintain or achieve stability or to prepare for expeditionary operations?
5. What possible mission scenarios have been considered to date and please provide us with a "brief" analysis of their work?
6. When mission planning, what Army forces are considered essential, and why?
7. What factors impact on the selection of service capabilities; e.g., deployment time, sustainment requirements, total head count?
8. How does joint logistic capabilities provided by the Army factor into your CCMD force requests?
9. When you (the CCMD) set your requirements for military forces, what parameters do you take into account - e.g., lethality, suitability for the terrain/conditions, logistics consumption and what that implies for lift/sustainability? Or do you focus instead on parameters like number of boots on the ground or simpler measures of military presence?
10. Do you ask for specific units or types of units (e.g., 82 Airborne; IBCT; Stryker BCT; Armored BCT) or just describe the military capability you are seeking in more general or generic terms?
11. Do you plan considering mission duration- is that specified when you set your requirements or is it more open-ended?
12. What measures do you use to establish whether the force that you are requesting will not impose an undue burden on the civilian population re: water consumption? Do you consider the need to effect civilian population attitudes/behaviors? How does that consideration affect troop requirements?
13. What potential scenario(s) cause you most concern with respect to land combat/maneuver?
14. Why is that scenario of concern?
15. LTG Walker (ARCIC/TRADOC Commander) talked about a tooth top tail ratio today of 30/70 and that he wants to get to at least 50/50. If that is the case, what are the CCMDs willing to do with less?
16. What are their support priorities and what are they willing to do without?
17. What alternatives (joint force trades, technologies, etc.) might enable reducing the support tail?
18. How are contractors on the battlefield considered/calculated when planning operations?
   When planning for potential future conflicts (or war gaming)?
19. How do you account for precision munitions in calculating mission effectiveness and logistic support?

20. Is the precision of your munitions a factor in potential near term conflicts? How about 2025 and beyond?
21. Have large artillery rounds such as Excalibur been factored into future conflict scenarios and if so what kind of scenarios are affected?
22. If you had munitions that had, accuracies of a few centimeters at say 5km would that impact your strategy in terms of war fighting and logistics for munitions?
23. Will every engagement still require many "dumb bullets" and if that is the case what is the impact of smart munitions?
24. What requirements do you foresee for US ground forces in the 2025 timeframe? How do those differ from current planning?

Army War College (MG Cuculo, April 2014)

1. What is the Army's primary mission in 2025, given the contemporary reluctance to deploy ground forces (e.g. Libya)? Humanitarian? Peacekeeping?
2. How does the Army project sufficient strategic power without forward basing?
3. What current technology has had the greatest influence on modern warfare and what will succeed it?
4. What is the role of Special Operations vis a vis General Purpose forces in 2025? How can the Army better leverage this relationship?
5. What should operational commanders know about cyber and ISR from an expeditionary context? What is AWC doing to prepare them?
6. What internal issues constrain the Army's ability to achieve strategic maneuver?

Army Research Laboratory (May 2014, Adelphi, MD)

1. What are the advanced concepts that you might be working on that would support Expeditionary Maneuver, these include, materials, intel systems, sensors, even human decision making, others?
2. What technologies or decision making processes are you looking at that would meet the challenges identified by Task 1 and are listed in Task 2 of the TOR?
3. What concept could support approaches for human connections to better gain support from host countries
4. What do you believe are the gaps that the Army should invest in to make them more maneuverable?

NDIA Robotics Meeting (May 2014)

1. What are your measures of performance and effectiveness?
2. How might robotic capabilities such as those being developed in the DARPA LS3 (Legged Squad Support System), a robotic "mule capable of carrying 450 lbs. of soldier support equipment, contribute to Army Expeditionary Maneuver? Could there be much of an impact on tooth-to-tail ratio?
3. Do robotics experts expect that by 2025 many of these capabilities could be sufficiently mature to provide significant support to Army expeditionary forces?

Army Sustainment Command (June 2014, MG Wharton, Rock Island, IL)

1. What 'Regional Aligned Force' activities are being accomplished and being planned? What are the benefits of Regionally Aligned Forces? How does this affect LOGCAP?
2. What activities do you perform (or plan) in any regionally aligned areas during peacetime?
3. What activities do you need to have accomplished to maintain or achieve stability or to prepare for expeditionary operations?
4. What possible mission scenarios have been considered to date and please provide us with a "brief" analysis of their work?
5. When mission planning, what Army forces, to include LOGCAP are considered essential, and why? What factors impact on the selection of service capabilities; e.g., deployment time, sustainment requirements, total head count?
6. How does joint logistic capabilities provided by the Army factor into your LOGCAP planning?
7. When you (the ASC) set your LOGCAP requirements, what parameters do you take into account - e.g., lethality, suitability for the terrain/conditions, logistics consumption and what that implies for lift/sustainability? Or do you focus instead on parameters like number of boots on the ground or simpler measures of military presence?
8. Do you plan considering mission duration- is that specified when you set your requirements or is it more open-ended?
9. What measures do you use to establish whether the force that you are requesting will not impose an undue burden on the civilian population re: water consumption? Do you consider the need to effect civilian population attitudes/behaviors? How does that consideration affect LOGCAP requirements?
10. LTG Walker talked about a tooth top tail ratio today of 30/70 and that he wants to get to at least 50/50. If that is the case, what are the COCOMs willing to do with less? What are their support priorities and what are they willing to do without? What alternatives (joint force trades, technologies, etc.) might enable reducing the support tail? How are contractors on the battlefield considered/calculated when planning operations?

ARDEC (June 2014, Picatinny Arsenal, NJ)

1. What do ARDEC technologists and system developers consider to be the most notable benefits of precision fires / precision munitions, enhance lethality, etc. on future Army Strategic and Expeditionary Maneuver capabilities?
2. How significant could their impact be?
3. How will advanced weapons technologies, precision fires, and enhanced lethality impact future warfighting tactics?
4. What is the comprehensive range of ARDEC precision munitions and lethality work?
5. What might be sufficiently matured to be exploited in the field by 2025?

NSRDEC (June 2014, Natick, MA)

1. Given that many future operations will occur in cities, what is Natick doing to find ways to forage for power and energy to support soldiers? e.g. converters, battery chargers, microgrids

2. What are the prospects for better batteries between now and 2025?
3. Who has the responsibility for small robot power?
4. Can the Army ever achieve the same power efficiency in GOTS radios as COTS smartphones?
5. What are the realistic opportunities for small fuel cells?
6. What is the status of photovoltaics in fabrics?
7. In that same spirit, I'd just add that "better batteries" in my view means better power densities (more kw-hr/pound) and also faster recharge rates; plus better resistance to the elements and ability to operate in harsh environments without losing charge (e.g. deserts).

GOOGLE (June 2014, Reston, VA)

1. By 2025, what is the vision and implications of Google Earth for GEOINT?
2. What is the coverage of Street View and when will it be complete for Rest of the World (ROTW)?
3. Will global real time data streaming (e.g. video, telemetry) be common component of commercial GEOINT in 2025?
4. What are the global technical and social implications for Internet of Things (IOT)?
5. Will wireless universal broadband be available for ROTW? Will it be provided by LTE, wifi, or other?
6. What is the status of Google Loon? Will it be multi-functional, e.g include remote sensing, broadband communications, and LIDAR? Has the US Army approached Google on Loon?
7. What type of cyber security challenges likely in 2025? Is Cloud the universal solution?
8. What is Google doing to secure Android?
9. How will Android evolve to support military command, control, and integration with the IC Cloud?
10. Is there any collaboration with the Army on the autonomous systems?
11. What will be the state of vehicle autonomy in 2025?
12. What do you see are the biggest national security challenges facing US in 2025?
13. Can Google sense a particular country's "mood" in terms of social media?
14. Are you exploring cultural difference in social media?
15. What is the current state of real-time translation? Is real-time speech translation likely in 2025?
16. What should we know about the world in 2025 that should make us optimistic?

Journal of Commerce (July 2014)

1. How do you see the impact of the emerging 18,000 TEU containerships and the change in the trade patterns, especially the east west lanes and the north south feeder lanes?
2. How do you see the impact of the wide body B787 and A350 class of commercial aircraft on the air freight market?

MASERK (July 2014)

1. How do you see the impact of the emerging 18,000 TEU containerships and the change in the trade patterns, especially the east west lanes and the north south feeder lanes?

2. Are the load factors on the ships below capacity?
3. Would you consider carrying non-lethal cargo in a continuous route to be landed on demand?

AMRDEC (August 2014, Redstone Arsenal, AL)

1. What do AMRDEC technologists and system developers consider to be the most notable benefits of precision fires / precision munitions, enhance lethality, etc. on future Army Strategic and Expeditionary Maneuver capabilities?
2. How significant could their impact be?
3. How will advanced weapons technologies, precision fires, and enhanced lethality impact future warfighting tactics?
4. What is the comprehensive range of AMRDEC work involving precision fires/munitions, advanced warhead development, lethality, and advanced sensors?
5. What ongoing developments might be sufficiently matured to be exploited in the field by 2025?
6. What ongoing work at AMRDEC is directed toward future Army heavy lift capabilities?

NYK and Hapag-Lloyd (August 2014)

1. How do you see the impact of the emerging 18,000 TEU containerships and the change in the trade patterns, especially the east west lanes and the north south feeder lanes?
2. Are the load factors on the ships below capacity?
3. Would you consider carrying non-lethal cargo in a continuous route to be landed on demand?

DASD-PS (August 2014)

1. How do you see the impact of the continued use of contingency contracting?
2. How do you see the emergence of calling of partner nations and non-governmental organizations for support and the impact on force structure requirements?
3. Do you see an expansion of contingency contracting outside of the logistical support functions?

JCS-J8 (August 2014)

1. How is GFM-DI being developed?
2. What is the timeline and how are the Services doing in maturing their approach to building the capability?
3. How is it going t0 affect planning for force employments and deployments?

FORSCOM G-3 (August 2014)

1. How is GFM-DI being developed?
2. What is the timeline and how are the Services doing in maturing their approach to building the capability?
3. How is it going to affect planning for force employments and deployments?
4. Can it be expanded to include capabilities below the unit level, to include the necessary support to enable those capabilities

AMAZON (September 2014)

1. How do they plan their logistics? How to they ensure efficient delivery of goods?
2. How are they progressing on the drone delivery system mentioned on 60 minutes last spring?
3. How do you deal with underperforming vendors?
4. Demand analysis, what decides what stays on the shelf or not?

APPENDIX E: STRYKER DEPLOYABILITY STUDY, 15 AUGUST 2011[53]

At the request of the TRADOC Analysis Center (TRAC) White Sands Missile Range (WSMR), the SDDC conducted ground, airlift, and sealift mobility analyses of force closure times for a Stryker Brigade Combat Team (SBCT). Three scenarios assessed deploying an SBCT from Joint Base Lewis/McChord to:

1. Bagram, Afghanistan
2. Sliac, Slovakia
3. Bangui, Central African Republic.

For all three scenarios, the Joint Flow Analysis System for Transportation (JFAST) model calculated the nautical miles and recommended number of enroute stops, while the Analysis of Mobility Platform (AMP) modeled the airlift and sealift deployments, and provided the force closure timeline. The number of dedicated missions generated five to six daily sorties from Joint Base Lewis/McChord. This mission departure sequence at Joint Base Lewis/McChord alleviated any throughput constraints at the origin or enroute airfields.

Assumptions for airlift included:

- C-17 allowable cabin load of 70 stons
- Availability of 20 C-17 (CONUS) aircraft daily
- Working maximum on ground (MOG) for C-17 aircraft of:
  — Two at Thumrait
  — One at Sliac
  — One at Bangui (daylight operations only)

Assumptions for surface mode transportation include:

- Large Medium-Speed Roll-On/Roll-Off ships (LMSRs) sail at 22 knots
- The Panama Canal is open

Deployment by airlift to Bagram, with aerial refueling and an enroute crew stop at Ramstein, Germany (Figure E.1) was assessed to require 320 C-17 sorties with shipments arriving in Bagram between days 2 and 58.

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[53] Source: Stryker Deployability Study, Final Report, 15 August 2011, prepared by Military Surface Deployment and Distribution Command (SDDC), Transportation Engineering Agency (TEA).

Figure E.1 Airlift to Bagram

An intermodal deployment to Bagram, where equipment is trucked to Tacoma (2 days), loaded on 2 LSMRs which sail to Dhofar (26 days), trucked to Thumrait, and loaded on C-17s for airlift, was assessed to require 320 C-17 sorties with delivery between days 31 and 47 (Figure E.2).

Figure E.2 Intermodal Lift to Bagram

A deployment to Sliac, Slovakia, where airlift is accomplished with aerial refueling and an enroute crew stop at Ramstein, Germany, used 320 C-17 sorties to have equipment arrive between day 2 and day 53. Alternately, surface deployment is accomplished by trucking equipment to Tacoma (2 days), loading it on 2 LSMRs which sail through the Panama Canal to Rijeka, Croatia (27 days), and then trucking it to Sliac (4 days), for arrival on day 33 (Figure E.3).

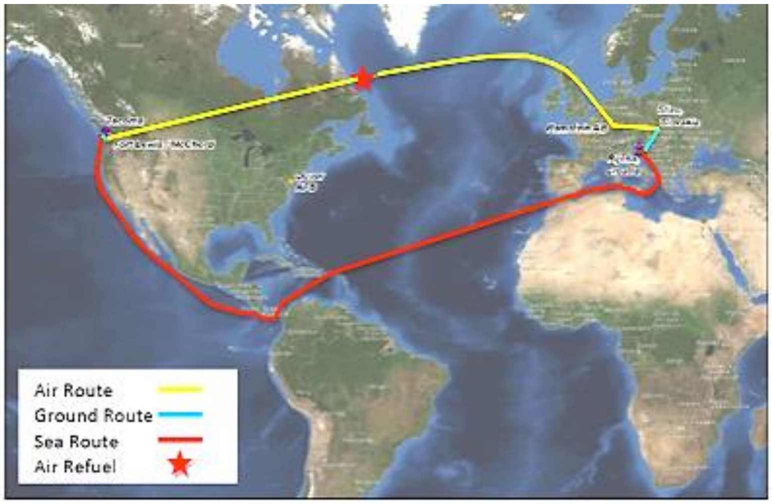


Figure E.3 Deployment to Sliac

A deployment to Bangui, Central African Republic would require airlift with aerial refueling and an enroute crew stop at Rota, Spain using 320 C-17 sorties to have equipment arriving between day 2 and day 58. Alternately, intermodal deployment is accomplished by trucking equipment to Tacoma (2 days), loading it on 2 LSMRs which sail through the Panama Canal to Rota, Spain (27 days), where it is then loaded on C-17s for transport to Bangui. The 320 C-17 sorties deliver the equipment at Bangui between day 27 and day 78 (Figure E.4).

Figure E.4 Deployment to Bangui

Based on the closure times established in the four scenarios, airlift alone provides arrival of SBCT equipment before day 27. Sealift to Slovakia, where the area of deployment is within driving distance of a major port, provides delivery of the complete SBCT in the most expeditious manner. Of the scenarios considered, intermodal deployment to Bangui takes longest because the airlift following sealift is time-consuming (Figure E.5).

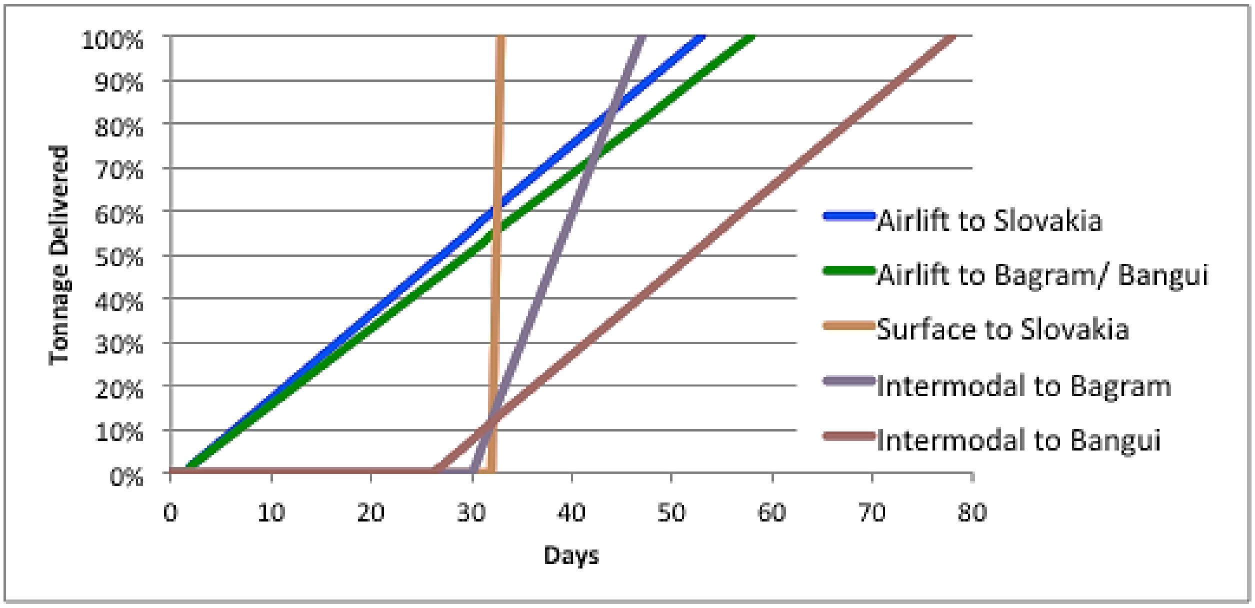
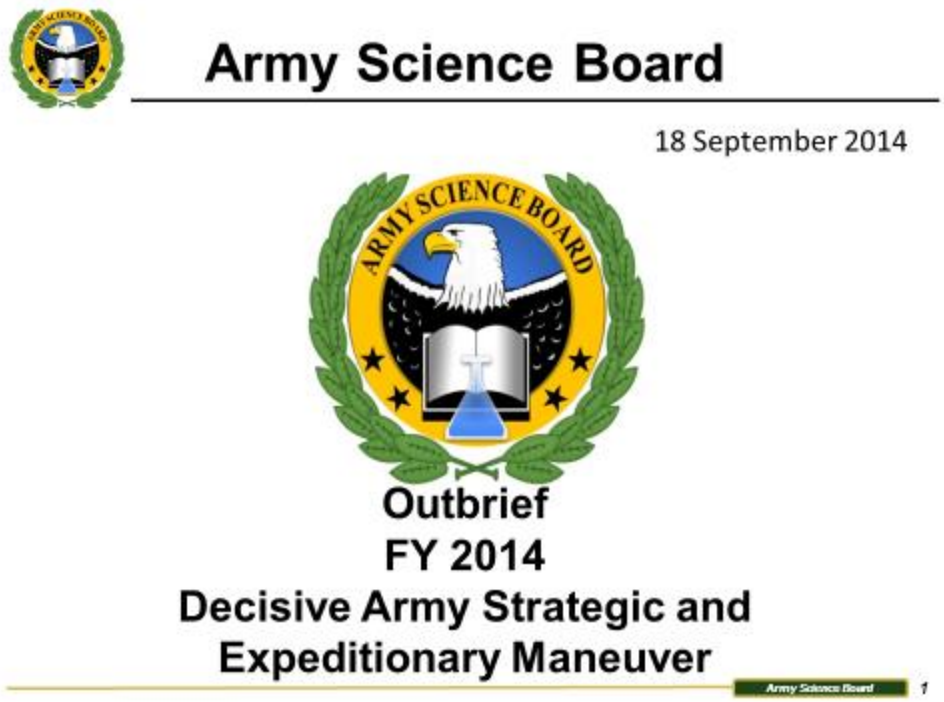
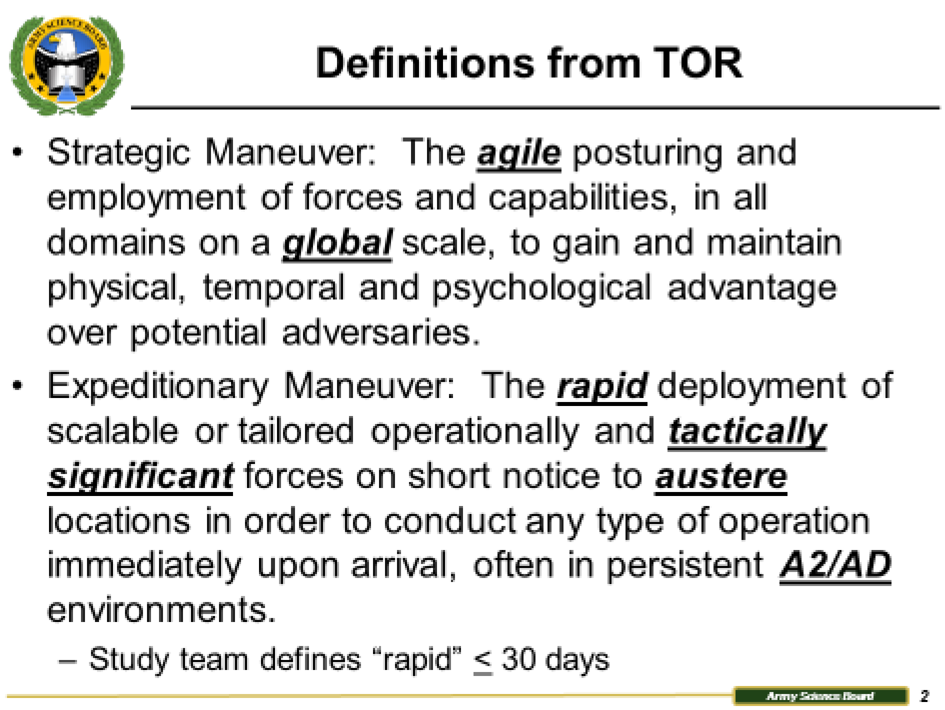


Figure E.5 SBCT Deployability Summary

APPENDIX F: ASB APPROVED BRIEFING WITH FINDINGS AND RECOMMENDATIONS, SEP 2014





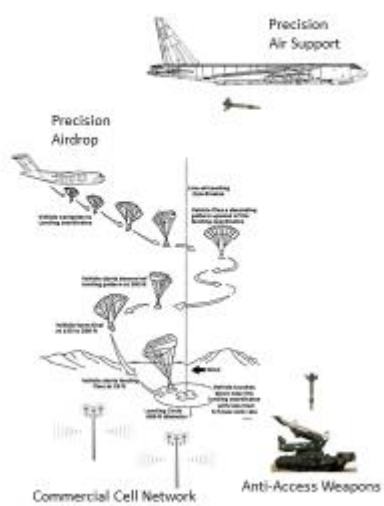
Concepts and Leveraging Opportunities for Strategic and Expeditionary Maneuver

- Dynamic capability-based deployment planning
- Synchronized distributed interdependent maneuver
- Counter-digitization
- Adaptive logistics support
- Leveraging of joint, commercial, and partner capabilities

Army Science Board 3

Roadmap

- **Introduction**
  - Study Overview
  - The Challenge
  - Key Trends
- **Concepts and Enablers**
  - **Comparative Analysis**
- **Leveraging Opportunities**
- **Other Innovations: 2025 and Beyond**
- **Summary**



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Study Overview

- **Terms of Reference**
  - Sponsored by CG Training and Doctrine Command
  - Critical Terms:
    - Assumes: *No additional military strategic lift beyond what is present today*
      - **TASK 1:** Identify the challenges that may compromise the operational forces' ability to successfully conduct strategic and expeditionary maneuver in ***2025***; recommend innovative advanced concepts; identify critical technologies, systems, and/or processes that might serve as enablers.
      - **TASK 2:** Identify options to leverage joint, commercial, and partnering opportunities.
      - **TASK 3:** Identify Army, other DoD, other USG, industry, university, and FFRDC research, technology, engineering and innovations for ***2025 and beyond***.
  - Schedule
    - Study conducted over the period January – July 2014
    - Briefing to be provided before 30 September 2014
    - Final Report to be submitted by 31 October 2014

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Study Organization, Visits, Interviews & Meetings

Experience

- **Study panel consists of 18 members**
  - **Areas of expertise:**

    Physics, Engineering, Computer Science, ISR, Air Defense, Modeling & Simulation, Rapid Manufacturing, Optics, Network Architecture, National Security, Analytics, Robotics, Autonomy, Program Management, SE&I, Military Space, Missile Systems, Munitions, Sensors, Aerospace Technology, Logistics, Materials, Acquisition, Sustainment
  - **Experience from:**
    - Academia
    - FFRDCs / National Labs
    - Defense contractors
    - Retired military & government officials

Data Collection

- **Conducted a total of 35 visits and interviews to date**
  - **DoD Organizations included:**
    - OSD/Joint: J8, DARPA, CENTCOM, USARPAC, USAREUR, SOCOM, TRANSCOM, OSD Rapid Fielding
    - Army: G3/5/7, 82nd Airborne, CASCOM, TRADOC, ARCIC, FORSCOM, ASC, ARCYBER, MCOE, ARL, AMRDEC, ARDEC, CERDEC, NSRDEC, TARDEC, Army War College, CAA CSA Strategic Studies Group
  - **FFRDCs/Academe:** RAND, GTRI, MITRE
  - **Industry:** Google, AUSA, NDIA, TEQ Games, Boeing, Maersk
- **Solicited input from 13 FFRDCs, Think Tanks, and Laboratories**

Army Science Board 6

The JOAC and JCEO Highlight Three Overarching Challenges*

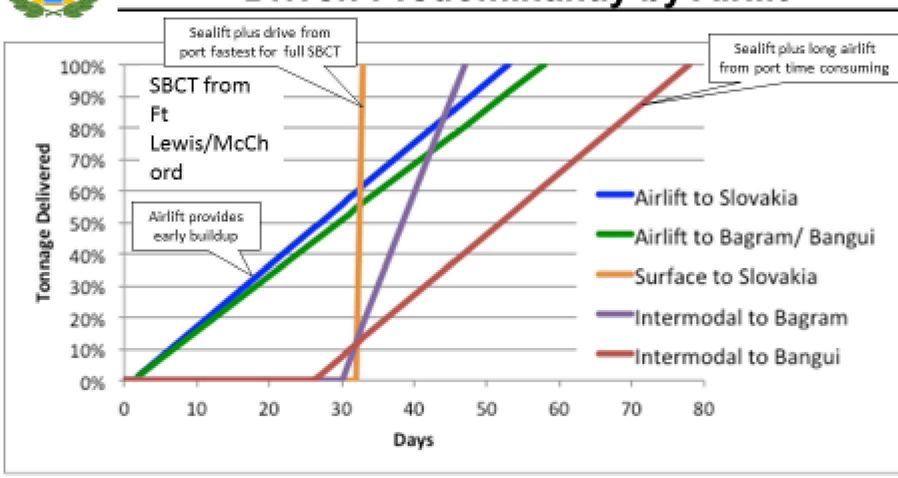
JOAC – Joint Operational Access Concept, 2012; JCEO – Joint Concept for Entry Operations, 2014

- The dramatic improvement and proliferation of weapons and other technologies capable of denying access (A2) or freedom within an operational area (AD)
- The changing U.S. overseas defense posture
  - Decreased support abroad for U.S. military bases
  - Unaffordability of garrisoning forces around the globe in response to every plausible threat
  - In age of increased terrorism, vulnerability of U.S. forces on foreign soil
- The emergence of space and cyberspace as increasingly important and contested domains
  - Priority domains for many future adversaries, both state and non-state

* Consistent with current draft of Army Operational Concept

Army Science Board 7

Another Challenge: Early Entry Capabilities Driven Predominantly by Airlift



Deployment to: Sliac, Slovakia; Bagram, Afghanistan; Bangui, Central Africa; (assumes 20 C-17s)
Source: Stryker Deployability Study, 2011, by SDDCTEA TRANSCOM

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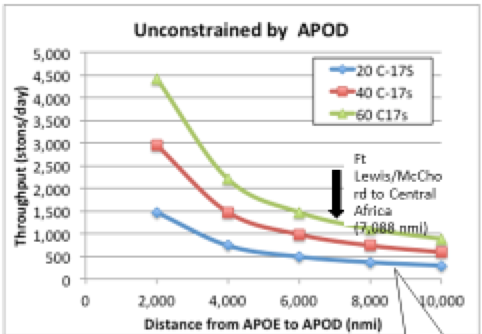
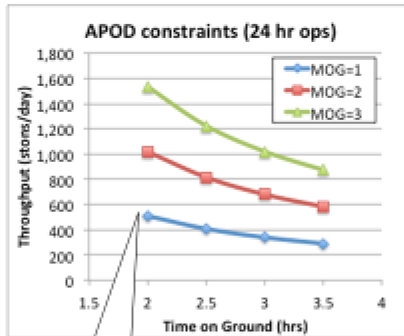
CONUS Basing and/or Austere APODs Constrain Initial Entry Force Size

Tyranny of distance



Impact of Austerity



Long distance equates to low throughput

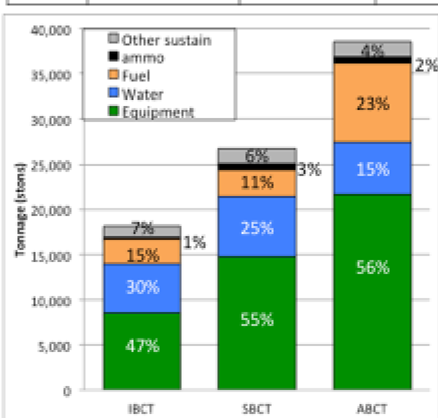
Low MOG equates to low throughput

To deliver a full SBCT (with sustainment) to Central Africa in 30 days would require over 800 stons/day; If APOD MOG =1, can't close full SBCT

MOG = Maximum on Ground (planes APOD can accommodate simultaneously)

Comparison: Time to Airlift BCTs

BCT Type	Nominal Weight*	Number C-17 sorties	Days if 2,000 nmi (20 C-17s)	Days if 7,000 nmi (20 C-17s)	% of tonnage to 7,000 nmi in 30 days (20 C-17s)
IBCT	18,192 stons	364	13	44	69%
SBCT	26,705 stons	534	19	64	47%
ABCT	38,489 stons	770	27	92	33%



*Assumptions:

- Weight includes 30-days sustainment (Arid Climate, Phase I-III Ops, Max Intensity)
- 50 ston average C-17 payload
- 0.7 days/sortie for 4,000 nmi round trip, 2.4 days for 14,000 nmi
- APOE and APOD do not constrain throughput

Take-aways:

- **Equipment and 30-day sustainment tonnage are comparable (do they need to be?)**
- **In first 30 days may need to fight without full BCT**

Key Trends Providing Additional Challenges and Opportunities for the Army

- Increased urbanization / growth of mega-cities
- Proliferation of advanced technology, including ubiquitous access to information technology
- Increased momentum of human interaction – compressed decision cycles / response times
- Improvements to capacity and efficiency in commercial air- and sea-lift

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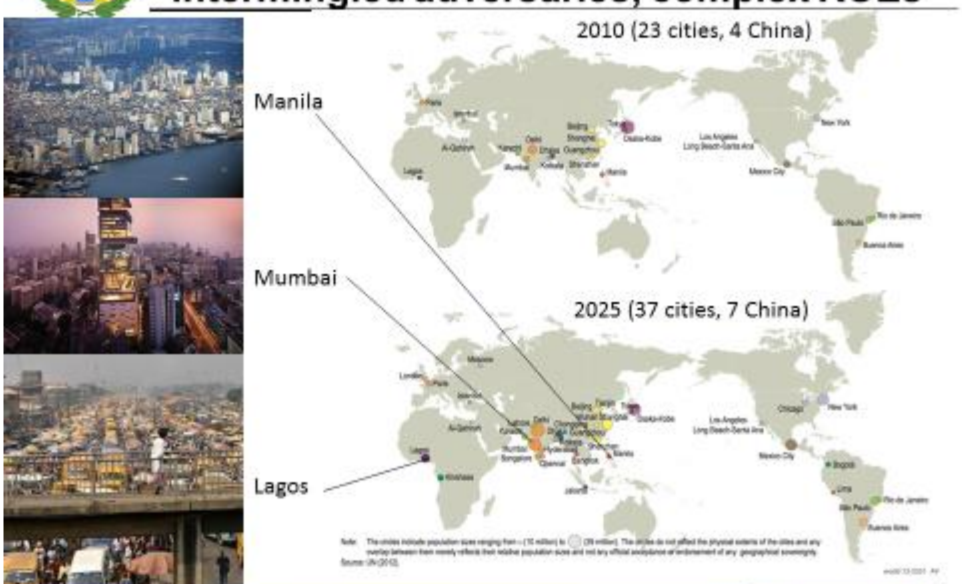
Challenges of Megacities*: 3D terrain, intermingled adversaries, complex ROEs



* Population greater than 10 million

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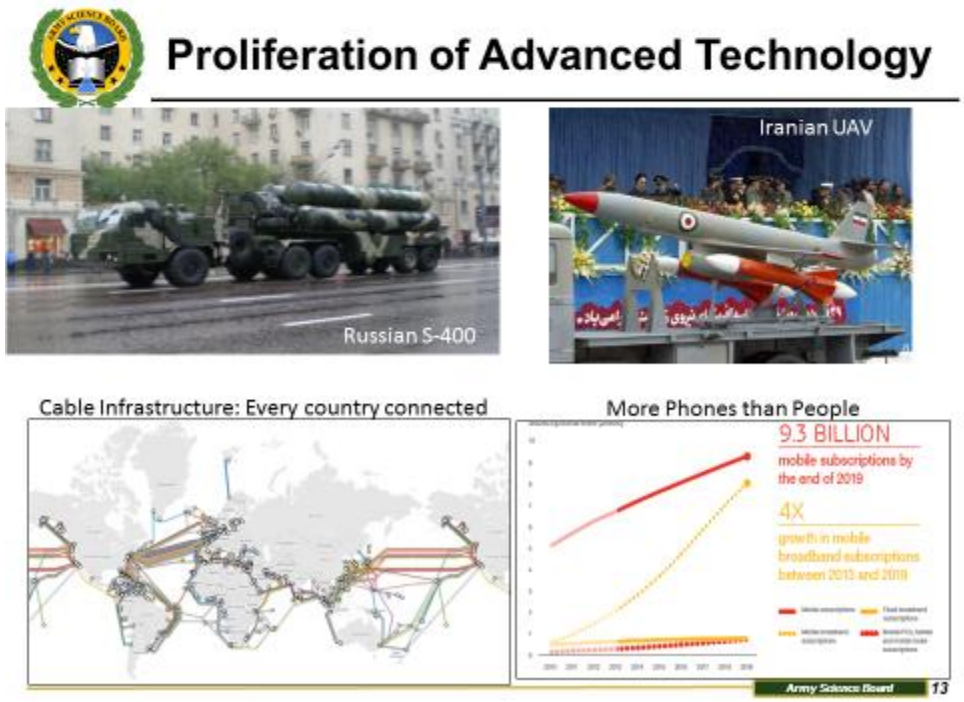
Proliferation of Advanced Technology
Russian S-400
Iranian UAV
Cable Infrastructure: Every country connected
More Phones than People
9.3 BILLION
mobile subscriptions by the end of 2019
4X
growth in mobile broadband subscriptions between 2013 and 2019
Army Science Board
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Proliferation of Advanced Technology
Iranian UAV
"By 2025 you will have a hard time *avoiding* being connected."
Vint Cerf, Chief Internet Evangelist, Google
Cable Infrastructure: Every country connected
More Phones than People
9.3 BILLION
mobile subscriptions by the end of 2019
4X
growth in mobile broadband subscriptions between 2013 and 2019
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Events Now Unfold In "Internet Time"

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Changes to Commercial Air- and Sea-Lift

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Changes to Commercial Air- and Sea-Lift

- Sales for widebody aircraft $5T over next 20 years
- One supplier: Current booked sales 92 billion ton-miles commercial airlift (vice 60 million ton-miles in previous DoD mobility requirements study)
- 777/787 class planes can carry 50 tons cargo or 300-400 passengers with 25 tons
- Standardized containers (LD3s) are norm
- Container lines moving from 8,000 to 12,000 TEU to 18,000 TEU ships on East/West routes

* TEU – Twenty-foot equivalent unit container

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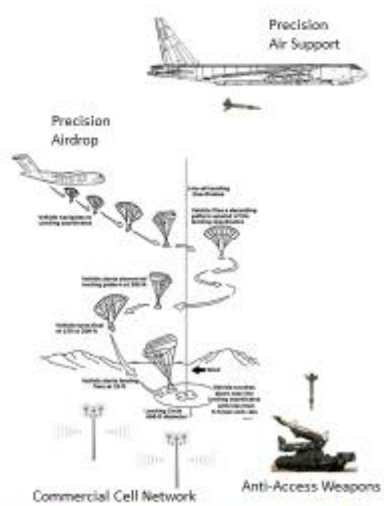

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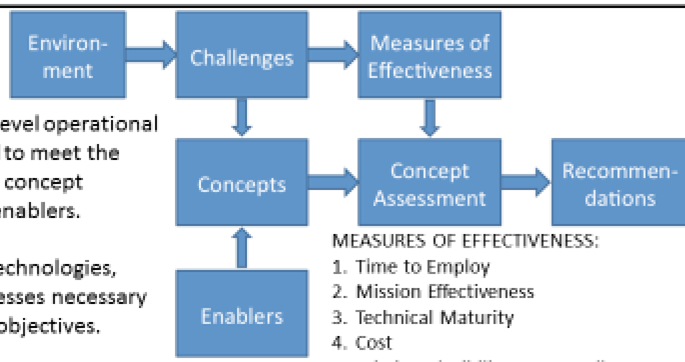
Approach



CONCEPTS: System-level operational solutions architected to meet the mission objectives. A concept integrates multiple enablers.

ENABLERS: Critical technologies, systems and/or processes necessary to meet the mission objectives.

ASSUMPTIONS:

- No additional strategic military lift
- Sustainment supplies available to ship when needed
- Budgets and force structure will follow current trends

MEASURES OF EFFECTIVENESS:

1. Time to Employ
2. Mission Effectiveness
3. Technical Maturity
4. Cost
5. Mission Flexibility Across Full Spectrum of Conflict
6. Capability Against A2/AD Threats and other counters
7. US Army Dependency on Outside Funding or Operations
8. Ethical, Legal, and Social acceptability
9. Sustainment of the Force (Maintainability, Medical, Contract)

Army Science Board 19

Objectives and Challenges for Strategic and Expeditionary Maneuver Vary by Phase of Conflict

C | C + 30

	Strategic Maneuver	Expeditionary Maneuver – Initial Entry	Expeditionary Maneuver – Follow-on Forces and Sustainment
Objective:	• Deter & Prepare • Secure Access Rights and Coalition Agreements	• Achieve Access • Secure Lodgment for Follow-on Forces	• Accomplish Mission
Deployment Means:	• Pre-Positioning	• Predominantly Airlift	• Predominantly Sealift
Challenges:	• Uncertainty & Volatility of Crisis Initiation • Constantly Changing Political Alliances Among State & Non-state Actors • Dynamic Deployment Planning in Response to Rapidly Changing Conditions	• Proliferation of A2/AD Threats • Austere Conditions at Points of Entry • Distance from CONUS - Based Forces to Area of Operations	• High Logistics Tail • Operational Maneuver in Face of Persistent AD

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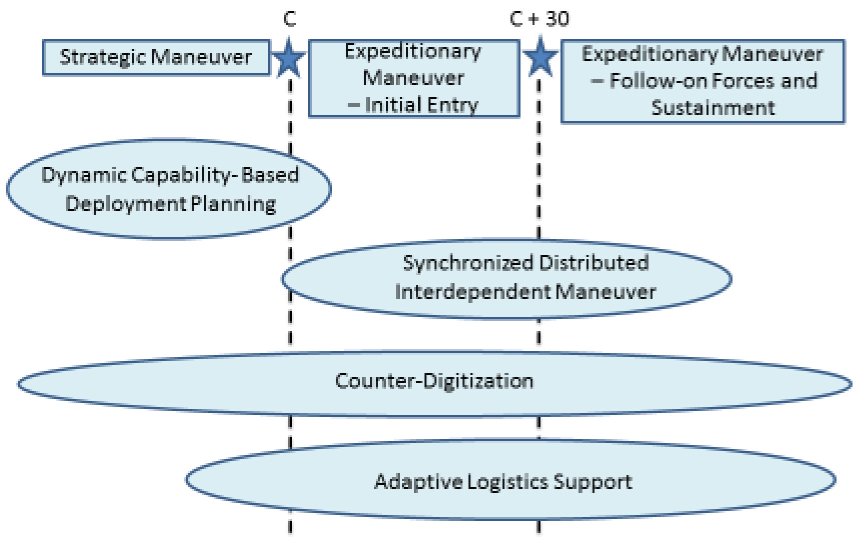
Advanced Concepts Cover All Phases of Conflict



Army Science Board 21

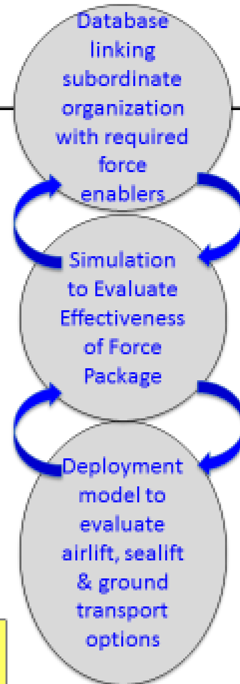
Dynamic Capability-Based Deployment Planning

- Joint Force Objective: Rapid, agile force planning in the face of compressed decision cycles
- Challenges
  - Optimizing use of limited air- and sea-lift
  - Units often take more personnel and equipment than needed for mission
  - Limited number of tools to enable planners to quickly tailor the force package
  - Deployment is often not included in training/exercises
- Concept
  - Forces better tailored to mission to optimize assets deployed
    - Permits prioritized, phased arrival of capabilities
    - Permits identification of sub-elements that may be unneeded
- Potential enablers that need integration
  - Structured database to identify enabling capabilities (GFM-DI)
  - Adjusted planning factors to support capabilities
  - Warfighting simulation to rapidly assess alternative force packages
  - Tool to assess deployment times associated with force packages (JFAST)
  - Dynamic tool to convert force packages, and sustainment, into JOPES
  - Training and exercises to explore tailoring, equipment loading, and rapid deployment

Army Science Board 22

Dynamic Capability-Based Deployment Planning Process

- Commander builds force packages using Army Unit Identification Codes (UICs) and subordinate UIC capabilities to provided needed capabilities
- Mission effectiveness simulation to assess if force packages can perform mission at acceptable level of risk
- Assess logistic support required to sustain the force deployment
- Deployment model used to estimate lift requirements and time of arrival for force package, including logistics
- Rapidly convert force package into data that can be integrated into JOPES/TPFDD for detailed deployment planning



Can fix the databases right away; models and simulation accessible on mobile devices by 2020

Synchronized Distributed Interdependent Maneuver

- Joint Force Objective: Achieve operational access in the face of armed opposition with A2/AD capabilities in order to secure lodgment
- Challenges
  - Avoiding predictable points of entry that become targets for A2/AD threats
  - Vulnerability of massed forces at a single entry point that are easily targeted by relatively unsophisticated ISR
  - Growth of "Mega-cities" as likely maneuver spaces
- Concept
  - Utilize small, mission-tailored units that are deployable into distributed entry points, including mega-cities
  - Maneuver interdependently to mass forces and close on the objective
  - Enhance small unit survivability through denial and deception
  - Enhance small unit lethality to enable immediate punch upon entry
- Potential enablers
  - Advanced Kinetic Munitions
  - Manned/Unmanned Teaming w/ semi-autonomous Lethal UGVs
  - Vertical Lift & Precision Airdrop
  - Deception ops (decoys, info ops, cyber)
  - Aerial Comms Layer
  - Mission Command on the Move

Unmanned Air Delivery in Austere Environments

Purpose: Provide unmanned means in an A2/AD environment for moving equipment and sustainment supplies forward

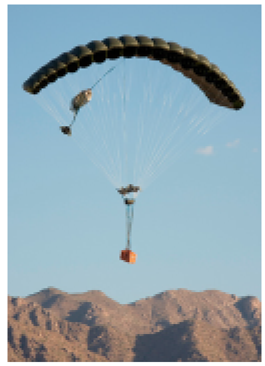
K-MAX
3 stons payload
demonstrated

Benefits of unmanned systems:

- Lower size, weight and cost than manned systems
- Reduced operational cost
- Lower risk for delivery into contested areas

Status:

- Commercially available now
- Used in Afghanistan



JPADs parafoil
5 stons payload
demonstrated

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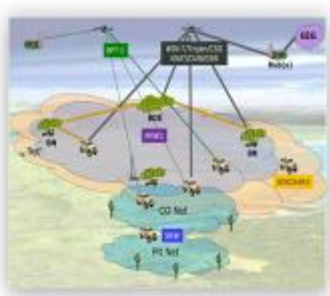
UAV Aerial Layer for Assured Communications

Purpose: Enable assured communications among distributed units in an A2/AD environment



Benefits

- Backup capacity if SATCOM goes down
- Reduced comms infrastructure
- Potential sensor network

Cellphone "Tower in the Sky"

Uplink Options:
Commercial
Satcom
Military Satellite
Link-16
Etc.

Platform Options

Downlink Options:
Cellular
SRW
HRN
Sincgars
Etc.

JOLTED TACTICS demonstrated secure 4G LTE network for tactical operations

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Precision Fires/Munitions (1 of 2)

- Provide significant force multiplier effect and enhance mission effectiveness with measurable logistics burden benefits (ammo, platforms, personnel, mission execution efficiency)
- Weapon types: Infantry support, artillery, ATGMs, long-range missiles, mortars
- Utility/effectiveness demonstrated by fielded systems: Javelin, EXCALIBUR, GMLRS, M795 155 mm PGK, APMI 120mm mortar
- By 2025, Army precision fires/munitions capabilities could be significantly enhanced by fielding of developmental systems if adequately funded; examples —
  - 40mm Extended Range Guided (ERG) Munition
  - XM1113 155mm Extended Range Projectile w/PGK
  - Mid-Range Munition (LOS/BLOS capability)
  - Improved EXCALIBUR 155mm Guided Projectile
  - 120mm High Explosive Guided Mortar (HEGM)
  - Low-Cost Tactical Extended Range Missile (LC-TERM)
  - Small Organic Precision Munition (SOPM)

HIMARS firing

- Considerations: Situational awareness (ISR), target location error, secure comms, GPS-denied environments, multi-purpose, scalable effects, affordability …

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Precision Fires/Munitions (2 of 2)

Unguided-to-Guided MLRS

Precision can enhance effectiveness and reduce logistics burden

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Courtesy of AMRDEC

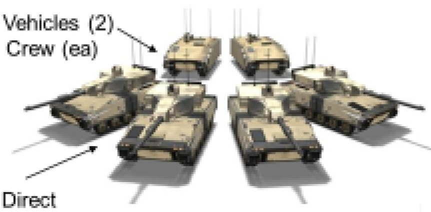
Manned/Unmanned Teaming: Semi-Autonomous Lethal UGVs

ABCT Abrams Platoon

- **4 Vehicles**
- **16 Crew**
- **Overall Weight: ~280 tons**

Concept Main Battle System (MBS) Platoon

Supervision Vehicles (2)
- 4 Person Crew (ea)



Unmanned Direct Fire Vehicles (4)

- **6 Vehicles**
- **8 Crew**
- **Overall Weight Goal: ~100-200 tons**

Benefits
- Significant overall weight savings
- Crew reduction through assignment of traditional functions to unmanned platforms
- Enhanced soldier survivability

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Courtesy of TARDEC

Counter-Digitization: Analog of ECM/ECCM for the 21st Century

- Joint Force Objective: Achieve technical overmatch and operational advantage against digitally-armed nation- and non-nation-state adversaries
- Challenges
  - Mitigating digital vulnerabilities across all phases of strategic and expeditionary maneuver owing to US reliance on digital systems
  - Exploiting similar vulnerabilities owing to adversary reliance
- Concept
  - Develop and grow an organic capability within the BCT to integrate fully kinetic, cyber, and electronic warfare effects
  - New approach to combined arms; potential game changer
- Potential Enablers
  - Counter-Navigation Technologies
  - Counter-Command & Control (C2)
  - Directed Energy
  - Electronic Battle Damage Assessment (BDA)
  - Exploiting "internet of things" in a secure manner

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Adaptive Logistics Support

Water + Fuel: 36-45% of BCT tonnage (1st 30 days)

- Joint Force Objective: Improve tooth-to-tail ratio
- Challenges
  - Strategic air and sea lift capacity is limited
  - Consumables demand a significant fraction of lift, especially fuel and water
  - Deployable communications infrastructure is heavy
- Concept
  - Exploit current commercial transportation trends to "change the game"
  - Reduce the amount of consumables deployed over long distances
    - Exploit local resources (e.g., bottling plants) whenever possible
    - Reduced platform level demand via fuel efficiencies
  - Exploit commercial communications assets
- Potential enablers
  - Commercial air cargo; shipping for mobile prepo
  - New expeditionary procurement agility to enable adaptation to local conditions and long-lead contracting
  - Energy-efficient platforms
  - Water production, use, reuse
  - Commercially available bandwidth and devices
  - Data-mining and analytics
  - Manufacturing in theater, e.g., selective 3D printing

Electric drive combat vehicle

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Commercial Aircraft Containerization

- A **unit load device** (**ULD**), is a pallet or container used to load luggage, freight, and mail on wide-body aircraft and specific narrow-body aircraft.
- LD3s, LD6s, and LD11s will fit 787s, 777s, 747s, MD-11s, Il-86s, Il-96s, L-1011s and all Airbus wide-bodies. Note: One of the design requirements of the 787, was for it to use the LD3/6/11 family of ULDs to solve the wasted volume issue.
  - LD3: Volume: 159 cu ft; Dimensions: 61.5 / 79 × 60.4 × 64 in
  - LD6: Volume: 316 cu ft; Dimensions: 125 / 160 × 60.4 × 64 in
  - LD11: Volume: 253 cu ft; Dimensions: 125 × 60.4 × 64 in

Unloading LD3 containers from a Boeing 747

Cross-section of an Airbus A300 showing LD3 containers

AA string of LD3 containers

Based on the evolving ubiquity of the LD3 type container, future systems that could accompany soldier deployment, should be designed for this volume / size / weight constraint space

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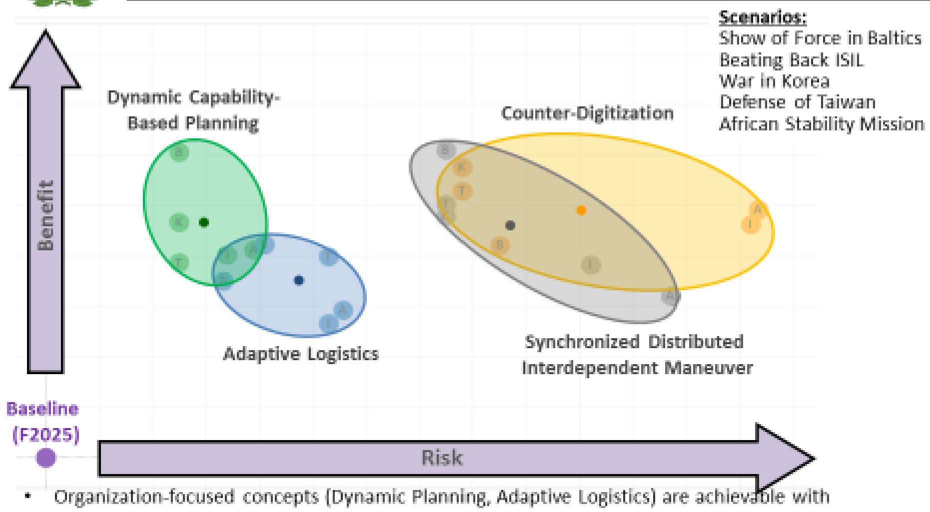
RAND QFD Analysis Tool Shows Risk vs. Benefit for Multiple Scenarios



- Organization-focused concepts (Dynamic Planning, Adaptive Logistics) are achievable with less risk than hardware-intensive concepts (Counter-Digitization, Synchronized Maneuver)
- Counter-Digitization and Synchronized Maneuver have comparable risk and benefit scores as well as the highest sensitivity to scenarios

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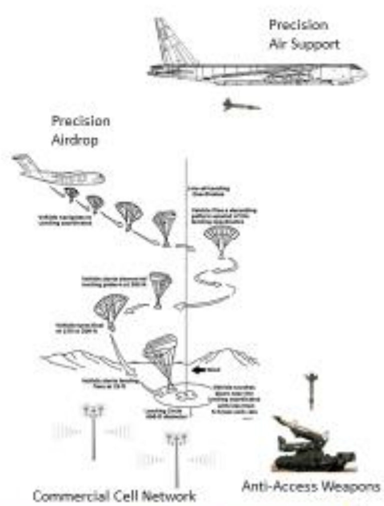
Roadmap

- Introduction
  - Study Overview
  - The Challenge
  - Key Trends
- Concepts and Enablers
  - Comparative Analysis
- **Leveraging Opportunities**
- Other Innovations: 2025 and Beyond
- Summary



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Leveraging of Joint, Commercial, and Partner Capabilities

- Joint: Tailor force capabilities to exploit Navy and Air Force assets when available
  - Hospital ships
  - ISR
  - Fire support / close air support
- Coalition Nations: Establish partnerships for prepo, stationing, and sustainment
  - Regionally Aligned Forces a positive step forward
    - Joint acceptance a key to long-term success
- Commercial: Mobile communications, cargo aircraft and ships, commercial IT

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Roadmap

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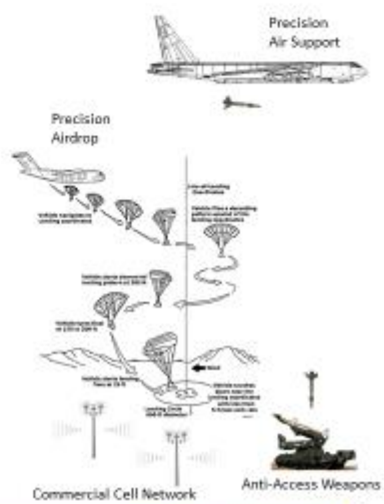

Army Science Board 36

Beyond 2025 Technologies Supporting UQ13 Objectives (1 of 2)

Unified Quest 2013 Goals and Results	Automated offensive and defensive cyber	Semi-autonomous and autonomous systems	Sense-making data fusion, wide-area ATR	Fusion of LIDAR and EO sensors, Green-sensitive camera, Air-cooled laser
Swiftness of action must be balanced with security, survivability, and sustainability	X	X	X	X
Reduce predictability with multiple entry points	X	X	X	X
Dominate the human domain to shape the environment and set conditions	X			
Network protection is critical; offensive methods had limited effects on the plan	X	X		
Formations, capabilities, mobility of sustainment forces can limit speed, agility, and endurance	X	X	X	X
Fuel consumption and lack of host nation support is realistic challenge	X	X		X
Mass effects to create shock through cross-domain dominance and integration	X	X	X	
Rapidly aggregate/disaggregate combinations of Army and Unified Action Partners	X	X	X	
Sustain agile operations	X	X	X	X
Deter use or proliferation of WMD	X	X	X	X
Promote intervention legitimacy	X	X	X	X
Deter civilians from interfering with operations	X	X	X	X
Degrade paramilitary and terrorist capabilities	X	X	X	X

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Beyond 2025 Technologies Supporting UQ13 Objectives (2 of 2)

Unified Quest 2013 Goals and Results	Multipurpose and precision fires/ munitions (CEP ≤1 meter)	Anti-missile and advanced directed energy	Deployable desalination, water treatment and purification	Advanced high-performance materials	Fuel Cell, Scaling up Zn-air, 45% efficiency PV	Thermoelectric on waste heat
Swiftness of action must be balanced with security, survivability, and sustainability	X	X	X	X	X	X
Reduce predictability with multiple entry points						
Dominate the human domain to shape the environment and set conditions			X			
Network protection is critical; offensive methods had limited effects on the plan	X					
Formations, capabilities, mobility of sustainment forces can limit speed, agility, and endurance	X	X	X	X	X	X
Fuel consumption and lack of host nation support is realistic challenge			X	X	X	X
Mass effects to create shock through cross-domain dominance and integration		X		X		
Rapidly aggregate/disaggregate combinations of Army and Unified Action Partners						
Sustain agile operations	X	X	X	X	X	X
Deter use or proliferation of WMD	X	X				
Promote intervention legitimacy	X					
Deter civilians from interfering with operations						
Degrade paramilitary and terrorist capabilities	X	X				

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Roadmap

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  - Key Trends
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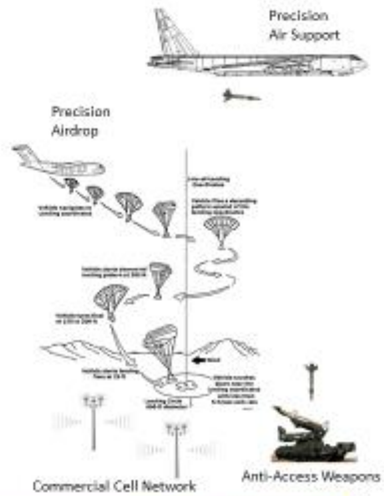

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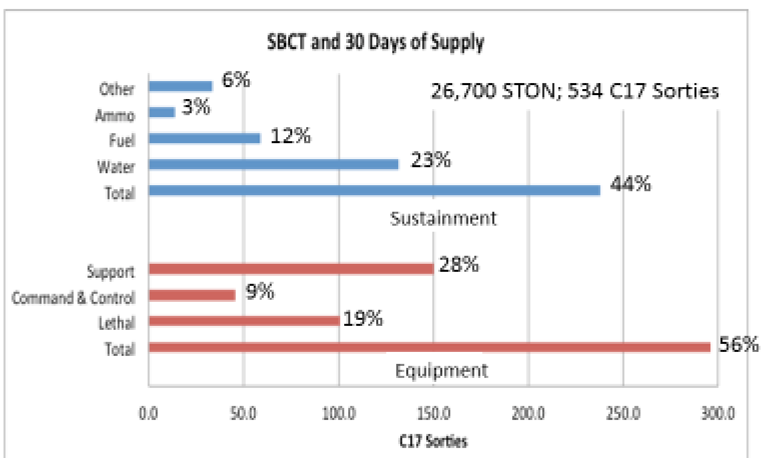
Enhancing Maneuver: Six Key Areas of Impact

- Water
- Fuel
- Ammo
- Footprint
- Time to Deploy
- Lethality/ Survivability



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Army Can Enhance Strategic and Expeditionary Maneuver Now without New Program Starts

Enablers	Primary Areas of Impact
Decompose TOE capabilities to enable a planning database linking subordinate organizations with required force enablers	Time, Lethality/Survivability
More existing precision fires/munitions, fewer dumb rounds, especially with early entry forces	Lethality/Survivability
Use Live Virtual Constructive (LVC) simulations for preliminary evaluation of concepts	All
Develop plans/new contracting paradigms to enable *contracting at the speed of expeditionary maneuver*:	
• Leverage commercial sealift - Mobile prepo at sea	Water, Fuel, Time
• Leverage commercial airlift - Account for LD3 containers in unit outload	Water, Ammo, Time
• Leverage in-area sources of water (e.g., bottling plants)	Water, Time
• Exploit existing commercial communications in area of operation (e.g., cellular network)	Time, Footprint
• Exploit existing commercial power supplies in area of operation (electrical, fuel)	Fuel, Time, Footprint

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Enhancements that Can Be Demonstrated by 2020 (1 of 2)

Enablers	Primary Areas of Impact
Capability-Based Deployment Planning simulation and models	Time, Lethality/Survivability
Small unit mobile devices for ISR and SA	Lethality/Survivability
Exploit commercial developments to better utilize the ubiquitous information environment	Water, Fuel, Ammo, Time, Footprint, Lethality/Survivability
Expand use of existing UAVs for ISR, aerial net, targeting	Footprint, Lethality/Survivability
Cargo movement by UAV (light-to-medium), precision airdrop	Water, Fuel, Ammo, Time, Footprint, Lethality/Survivability
Improved ISR (sensors, LIDAR, other technologies)	Lethality/Survivability
Improved photovoltaic energy harvesting (structures, vehicles, ultimately soldier uniforms)	Fuel, Footprint
Selected counter-digitization effects	Lethality/Survivability
Semi-autonomous UGVs	Water, Fuel, Ammo, Time, Footprint, Lethality/Survivability

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Enhancements that Can Be Demonstrated by 2020 (2 of 2)

Enablers	Primary Areas of Impact
Improved energy harvesting (non-photovoltaic) – e.g., rectennas, mechanical	Fuel, Footprint
Directed energy weapons (RF, laser)	Time, Lethality/Survivability
Laser communications	Time, Footprint
Improved energy storage (batteries)	Footprint
Internet of Things (sensors on vehicles, weapons systems to report operational status over internet) (requires security paradigm)	Time
Use commercially available higher efficiency engines in vehicles	Fuel, Time, Footprint
Use available higher efficiency engines in rotorcraft	Fuel, Time, Footprint

Findings (1 of 3)

1. Proliferation of A2/AD threats affects early entry operations significantly
   – Conventional approaches involving the massing of forces in predictable ports of debarkation are especially vulnerable
2. CONUS basing and/or austere conditions severely constrain force size that can be deployed during initial entry
   – Tailoring of forces and sustainment to maximize mission effectiveness of initial entry forces becomes critical under either condition
   – In certain circumstances, availability of Joint capabilities can free up capacity for other, high-priority Army capabilities (medical services, fire support, ISR)
3. Mission command is critical to expeditionary maneuver
   – Historical overmatch in this area is eroding with the advent of social media and the ubiquitous spread of information technology
4. Vertical lift is an essential enabler for synchronized distributed interdependent maneuver via unpredictable entry points
5. Cyber and other digital systems will be increasingly subject to exploitation, denial, deception, and negation in 2025, exacerbated by reliance on commercial capabilities
   – Offers both opportunities and challenges for strategic and expeditionary maneuver

Findings (2 of 3)

6. Stovepipes resulting from Title 10 vs. Title 50 authorities disallow tactical exercises in the US that employ Title 50 systems
   – Impede warfighting functions critical to expeditionary maneuver
7. Mega-cities will confront the Army with new challenges requiring specialized and intensive pre-planning, advanced analytics, and regular training
   – Must operate in three-dimensional urban terrain, with intermingled adversaries and non-combatants, employing complex rules of engagement applied to a highly dynamic environment
8. By 2025, commercial advancements in many key areas will outpace those driven by the Army and DoD
   – Among others, mobile communications, cargo aircraft and ships, and commercial information technology can enhance significantly strategic and expeditionary maneuver
9. By 2025, DoD-sponsored advancements in selected areas will have matured to the point where they can be incorporated into Army operations
   – Semi-autonomous systems, hybrid-powered platforms, aerial layer communications and networking, precision fires/munitions all hold promise for reducing logistics burden

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Findings (3 of 3)

10. Beyond 2025, DoD-sponsored advancements in additional selected areas will have matured to the point where they can be incorporated into Army operations
    – Unmanned vertical heavy lift (25-30 ston payload), advanced directed energy weapons, etc.
11. Globalization may provide an opportunity to harness resource availability around the world (e.g., bottling plants, cellular providers)
    – Offsets logistics burden by taking advantage of indigenous resources
12. Partnering with other nations, non-governmental organizations, and commercial entities can enhance regional stability and may enable additional options for prepositioning, stationing, and sustainment support
    – Critical in austere and/or unfamiliar environments
13. Navy FY15 POM eliminates National Defense Sealift Fund, used in past to maintain surge sealift
    – Funding transferred to Navy O&M Ready Reserve Force ($291M) and Ship Pre-positioning and Surge ($106M) accounts
    – Contrary to prior Army/Navy agreements

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Recommendations (1 of 3)

CSA:

- Advocate for maintaining National Defense Sealift Fund to sustain capability for surge sealift; coordinate with Joint community

ASA(ALT):

- Ensure key technologies (e.g., semi-autonomous systems, hybrid-powered platforms, aerial layer communications and networking, precision fires/munitions) are addressed in BA4, BA3 (and BA2) funding plans
- In coordination with USTRANSCOM, AMC, G3/5/7, G4, and DLA: Develop the strategy and business case to exploit commercial assets for transportation, acquisition of supplies, and communications for the expeditionary force; consider new and improved vehicles to enable "contracting at the speed of expeditionary maneuver"

CG FORSCOM:

- With support from G3/5/7: Develop capability-based planning tools with sufficient granularity (company level and below) to optimize early entry force effectiveness and leverage joint capabilities (fire support, ISR, medical services) whenever possible; accelerate and expand Global Force Management Data Initiative to meet this purpose
- Execute Emergency Deployment Readiness Exercises (EDREs)

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Recommendations (2 of 3)

CG TRADOC:

- Develop and conduct Joint Concept Technology Demonstrations (JCTDs) and/or warfighting experiments for each of the four concepts identified in this study
  - Integrate the most promising concepts in end-to-end experiments
- Evaluate BCT force structure to determine if current force design supports expeditionary distributed operations using smaller units (company level and below)
- In coordination with G3/5/7, G2, and G6: Develop doctrine, training, TTPs, and technical capabilities to integrate kinetic, cyber, and electronic warfare effects as an organic BCT tactical capability to be incorporated in all operational planning; new approach to combined arms
- Develop integrated and interdependent CONOPS and evaluate operational utility for distributed maneuver using near-term non-developmental items (NDIs) for vertical lift and precision airdrop; initiate requirements assessment for a future unmanned heavy lift vertical system for JLOTS and mounted vertical maneuver

Director ARCIC:

- In coordination with RDECOM: Beginning with concepts identified in this study, conduct detailed DOTMLPF analysis on concepts and enablers by end of 2015

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Recommendations (3 of 3)

G3/5/7:
- Set requirement to reinstitute Emergency Deployment Readiness Exercises (EDREs)
- Review readiness issues resulting from Title 10/Title 50 authorities and, as required, articulate path forward to remove constraints on CONUS-based BCT training with Title 50 systems
- Designate a specialized BCT testbed for expeditionary urban operations to develop doctrine and training required for operating in mega-cities; leverage Army National Guard presence in US mega-cities for relevant civilian skillsets
- In coordination with USTRANSCOM, AMC and DLA: Expand concepts for strategic partnering to leverage partner contributions (including logistics) in future operations
- With G4 and TRADOC: Review sustainment planning factors for deployment in expeditionary maneuver

CG Maneuver COE:
- With support from CG Cyber COE: Make counter-digitization part of the maneuver, fire, and effects warfighting function

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Concepts and Leveraging Opportunities for Strategic and Expeditionary Maneuver

- Dynamic capability-based deployment planning
- Synchronized distributed interdependent maneuver
- Counter-digitization
- Adaptive logistics support
- Leveraging of joint, commercial, and partner capabilities

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